POWER PLANT ENGINEERING

Established Over 33 Years

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Contents of this Issue

	Page
More Ice for Boston	452
Essentials of a Heat Factory. By A. A. Potter and H. L. Solberg	459
U. S. Shipping Board Conducts Tests on New Pulverized Coal Equipment for Marine Service	462
Boiler Operation Improved by Mixed Fuels. By R. C. Demary	464
Combination Air Preheater and Economizer Developed by British Engineer	466
Pure Air Increases Power of Combustion Engines	467
Balancing Heat and Power in Industrial Plants. By R. V. Kleinschmidt	469
Stop Losses in Services Rendered to the Plant	471
The Care of Switch Oil. By W. E. Warner	473
Features of A. C. and D. C. Bus Bar Design. By T. H. McCauley	474
Electricity—What It Is and How It Acts. By A. W. Kramer	478
Practical Methods of Oxy-Acetylene Welding. By L. A. Cowles	482
Philtower Building in Tulsa Burns Gas	484
How Alabama Power Co. Uses Models to Predict Performance of Hydraulic Structures	486
Superiority of Factory Generated Power. By F. S. Rutledge	488
Removal of Ash in Molten Slag Form	489
Letters Direct from the Plant: Building Up a Motor-Generator Set. Furnace Construction and Fuel Changes Overcome Operation Troubles. Pump Shaft Sleeves Removed by Use of Nut. Shaft Coupling Removal. Hose Racks from Old Carbide Cans. Homemade Metallic Packing Serves Well. Mounting Pulley on Housing Eliminates Shaft Deflection	490
Questions and Answers: Mold for Babbitting Crosshead Shoes. Wetness of Live and Exhaust Steam. Weight Change on Shaft Governor Changes Engine Speed	493
Editorial Comment: Engineering Education Takes a Long Step Forward. Training Power Plant Operators. Duty Performed as an Art Is Its Own Reward	494
Off Duty	495
Packless Type Solenoid Valves	496
Current Transformers with Hipernik Cores	496
Steam Trap Has Self-Cleaning Valve	497
Riley-La Mont Water Wall	497
Pioneer Dynamo to Light Ford's Historical Exhibit	498
A. S. M. E. Knoxville Meeting Well Attended	498
American Welding Society Meets April 24-26	499
Electrical Engineers Meet in Cincinnati	500
News Notes	501
Power Plant Construction News	502

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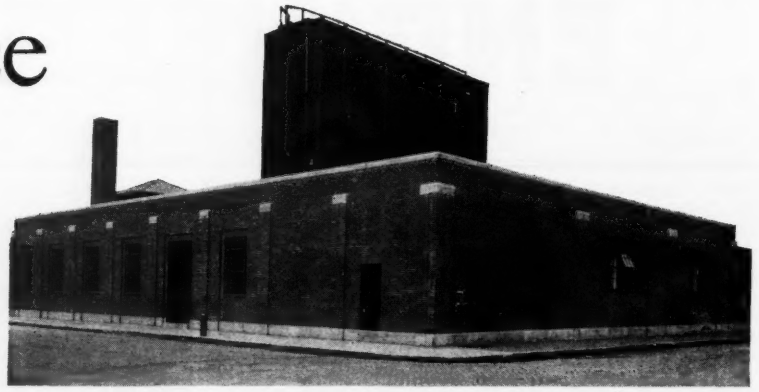
When Knighthood was in Shower

IN THE DAYS when all gentlemen were supposed to be chivalrous, the training that the young men got in the manly art of self-defense with a sword and shield and clad in an armour of steel was long and arduous.

Altogether, the budding knight had to go through a lot of inconveniences. He had to learn to ride a horse with a saddle that pounded him in the middle of his back at every step of the horse and it was quite an art to pull his feet out of those old-fashioned stirrups when his horse threw him by shying at a wind-blown newspaper. Then there were the horses to curry and shoe and the spears to mend at the forge and sharpen on the emery wheel. Blisters, bruises and bunions aplenty were caused by ill-fitting armor and wounds had to be painted with mercurochrome and bathed in boric acid water. The tournaments made the turnover of hardened knights large and the profession was rapidly exterminated. Just try to find a knight now!

Well, these knights left their hoods behind and scientists in trying to find some industrial use for them and thus prevent antique collectors from putting them (the hoods) into disuse, developed the art of welding and cutting with gas and electricity. No doubt you have often wished you could be a knight; a very laudable wish indeed, one which is not at all impossible of attainment as you will perceive by reading the article by Mr. Cowles on page 482.

More Ice *for* Boston



New Cambridge plant described here is only one of many new plants built by the Boston Ice Co.

DURING THE PAST YEAR, the Boston Ice Co. has built and placed in operation in and around the city of Boston a number of new, highly efficient, electrically operated ice plants, one of which is the Cambridge plant described in this article. While these plants differ as regards arrangement of equipment and, to a certain extent, as to make of equipment, they all have the same general characteristics. Naturally, the later plants benefit somewhat by the experience obtained in the construction and operation of some of the earlier plants, therefore they may be expected to be slightly more efficient but all of them represent the latest and best in refrigerating practice.

Of these plants, the Cambridge plant together with the Dorchester plant are the two newest although at the present time the company is building another plant at Malden. The Cambridge plant was built for a capacity of 200 t. daily and since it was started on August 3 of last year no difficulty has been experienced in easily maintaining this capacity; in fact, during the month of September, there were many days when the production was considerably in excess of this amount. The engineering features have been worked out particularly well and, as may be noted from the accompanying photographs, the appearance of the plant reflects careful thought on the part of the designers.

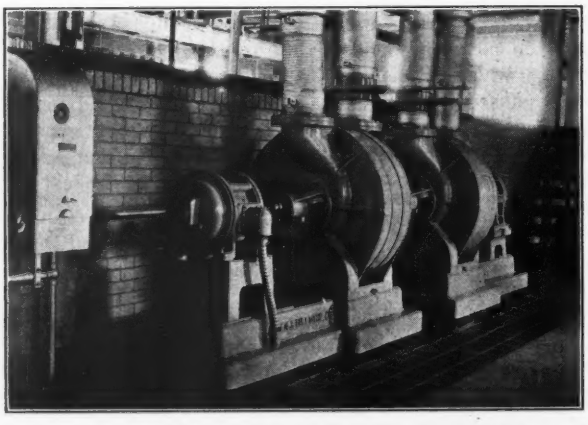


FIG. 1. TWO MOTOR DRIVEN BLOWERS DELIVER AIR AT 2 LB. PRESSURE TO THE AERATING SYSTEM

General Features

The building in which the Cambridge plant is housed is a one story structure of red pressed brick with a cooling tower built on the roof. Its external features are plain; no elaborate architectural features are provided, due to the industrial nature of the surrounding area.

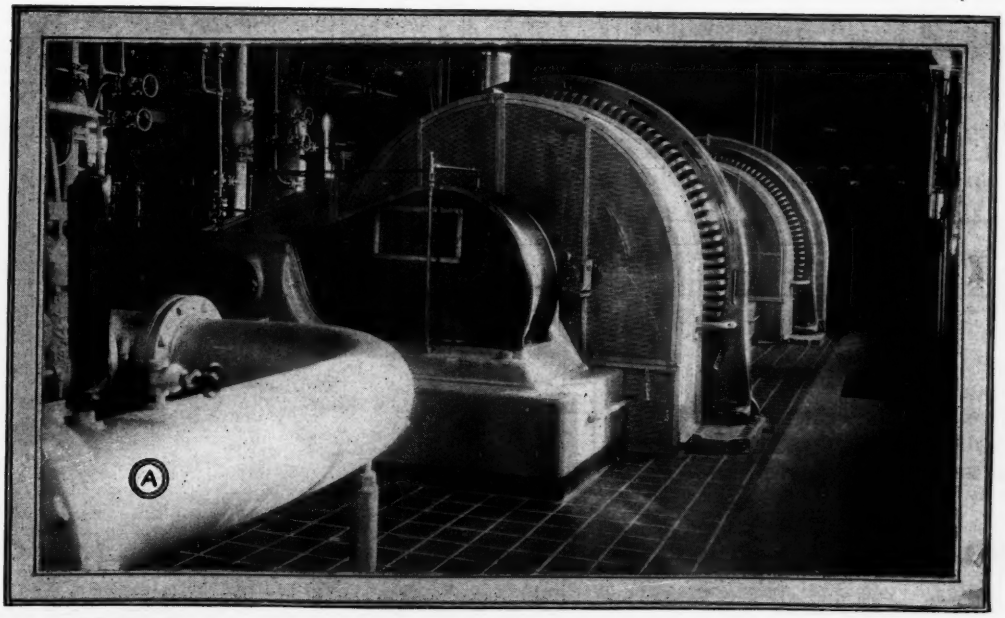
Inside, with the exception of the ice storage and boiler room, the plant consists virtually of one room. No dividing walls separate the machines from the ice tanks, so a clear view of all equipment in the plant is at all times possible. The building is well lighted—large windows on three sides insure absence of dark corners. The floors are of red square tile, the walls cream colored pressed brick and the ceiling of wood. All machines, with the exception of the ammonia condenser, are painted with a light cream enamel which harmonizes excellently with the coloring of the walls. All valves and fittings are painted aluminum with the control wheels in red.

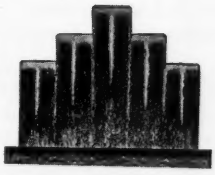
Power Supply

All machinery in the plant is operated by electric motors, current being purchased from the Cambridge Electric Co. of Boston. The main compressor motors operate directly at 2300 v., so transformers for these units are not required. For the motors driving auxiliaries, 440-v. current is used, this being supplied by a bank of three, single-phase Moloney transformers connected in delta rated at 37½ kw. each, and stepping down from 2300 to 440 v. Taps are provided on these transformers to secure accurate adjustment of voltage for the motors. One spare 2300/440-v. transformer is provided for use in emergencies.

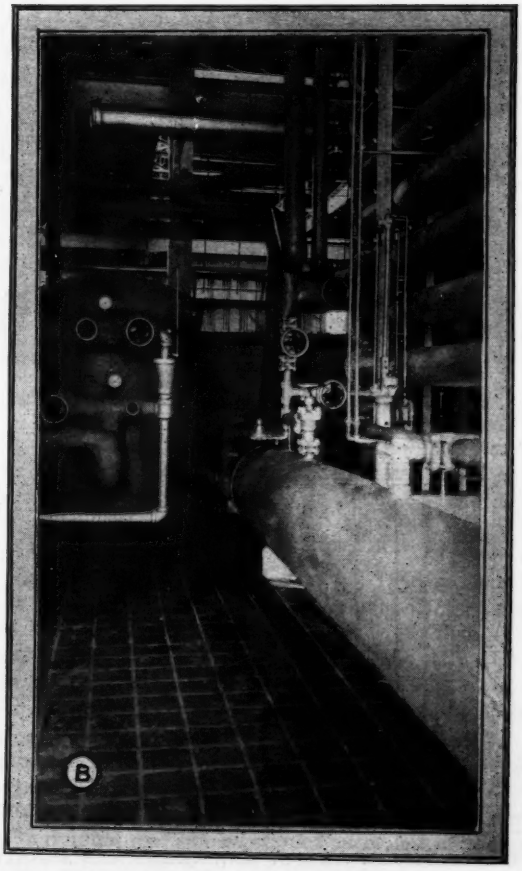
Three small transformers stepping down from 2300 to 110 v. are provided for lighting service and for a few 110-v. motors. The cranes as well as the ice cake stacker and the scoring machine in the ice storage room both use 110-v. current. These lighting transformers are 10-kv-a. units, also of Moloney manufacture.

All transformers, together with the incoming line





Exceptional care was taken in the design of the Cambridge plant to make it attractive in appearance. As can be seen from the photographs appearing on this page an atmosphere of neatness and cleanliness prevails. At A is shown a general view of the two ammonia compressor units. At B is a view alongside the ammonia condenser with the receiver shown in the foreground. At the rear can be seen one of the water filters. The manometer connected to the venturi tube in the ammonia line, for measuring the flow, may be seen at the right above the receiver.



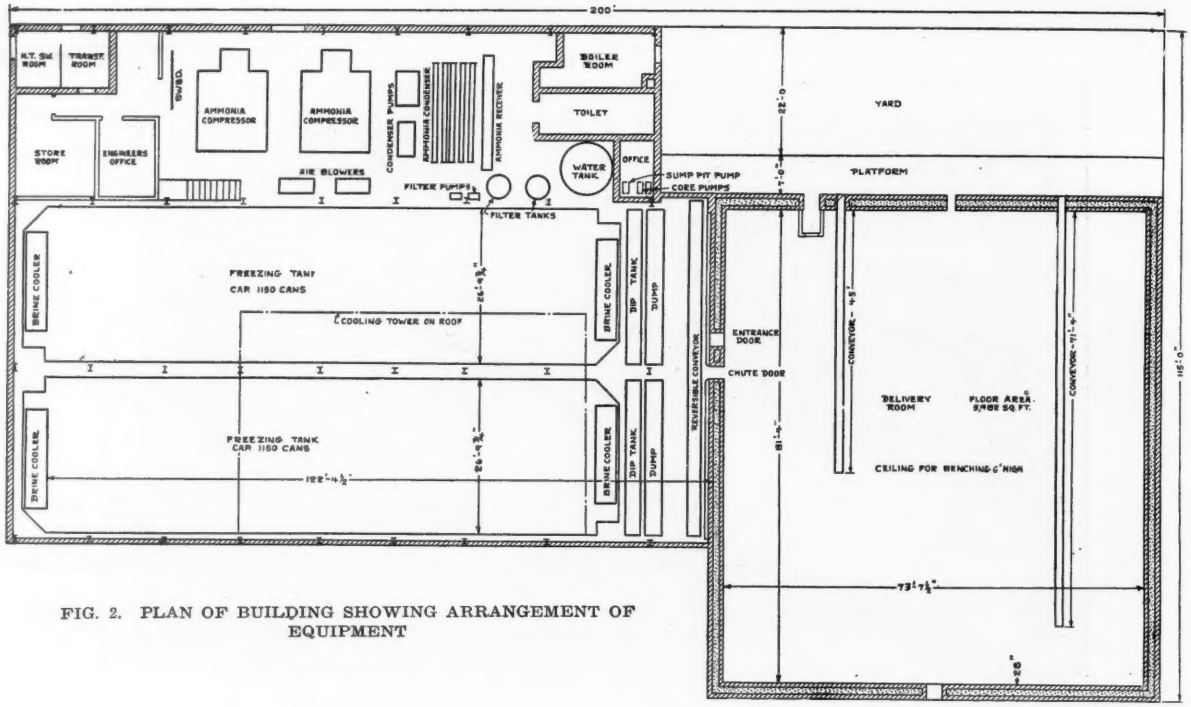


FIG. 2. PLAN OF BUILDING SHOWING ARRANGEMENT OF EQUIPMENT

switch, meter panel and 440-v. switches are installed in the transformer room shown in Fig. 2.

Two 100-t. ammonia compressor units are provided, each unit consisting of two type S De LaVergne horizontal duplex, double-acting compressors, driven by one motor. The compressors are 12 by 19½-in. machines giving a displacement per revolution of 17,643 cu. in. or a total displacement of 2,432,816 cu. in. when operating at the normal speed of 138 r.p.m. The displacement per ton of ice for the entire plant is 12,164 cu. in. The motors are Electric Machinery Co. synchronous machines rated at 300 hp., 100 per cent power factor, 2300 v., 61.2 amp., 138 r.p.m., three phase, 60 cycles. Each motor is installed at the center of the compressor unit so that a compressor is driven from each end of the motor shaft. A 7½-kw., 700-r.p.m., 125-v. direct current generator belted to the motor shaft on each unit, furnishes excitation for the fields. The proper excitation for full load operation at unity power factor is 48 amp. at 125 v.

Lubrication of the compressors is effected by the use of two Manzel force feed lubricators, belt driven from the compressor shaft. Oil is filtered and purified by a Bowser filter and reservoir on each machine.

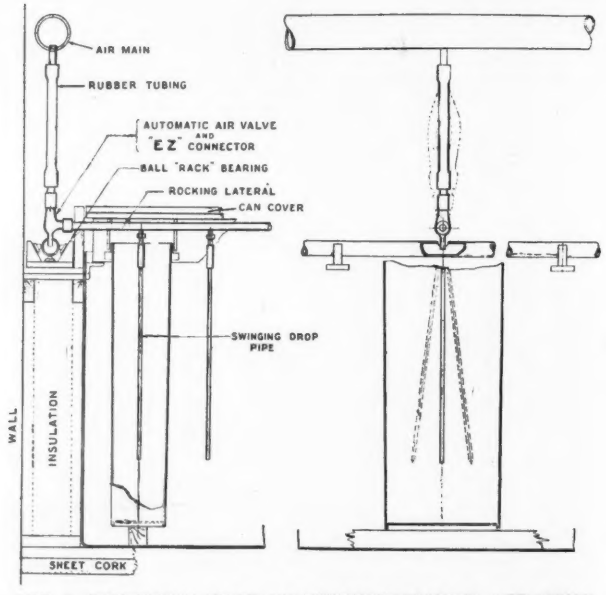


FIG. 3. SECTIONAL VIEW OF KNICKERBOCKER AERATING SYSTEM SHOWING AUTOMATIC AIR VALVE AND OPERATION OF MECHANICAL DROP PIPES IN CAN

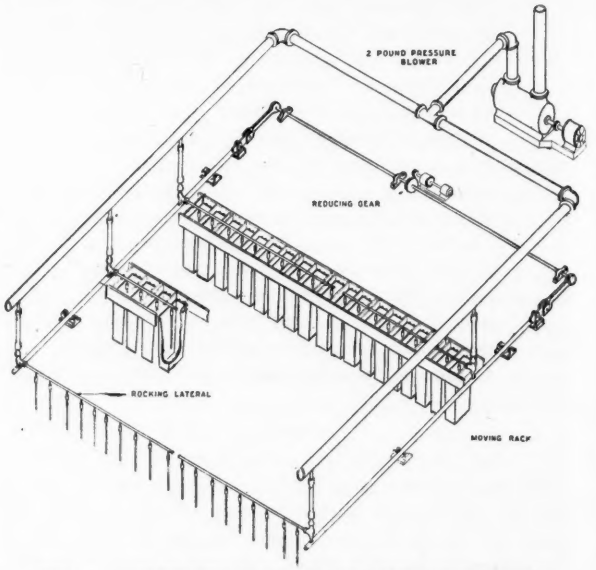


FIG. 4. COMPLETE LAYOUT OF THE MECHANICAL PENDULUM AERATING SYSTEM

Safety valves are installed in accordance with the standard code requirements, each compressor and brine cooler being provided with a relief valve, piped to a diffuser on the roof of the building.

The synchronous motors are controlled from a panel board in the compressor room, although the actual switches are in the transformer room.

Full protection against damage due to high pressure, caused by a failure of condenser cooling water, is obtained by automatic control devices which cut off the current to the driving motor when the pressure exceeds a certain predetermined value. This control equipment is located on the wall of the building directly in front of the compressors.

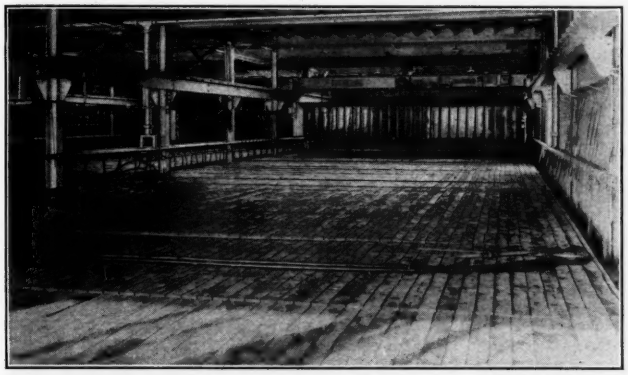


Fig. 5. View of freezing room, showing a full row of 25 cans being harvested at one time. Two freezing tanks hold 1150 cans of 300 capacity each or a total of 2300 cans. Along the sides may be seen the rubber tubes conecting the rocking laterals to the air main

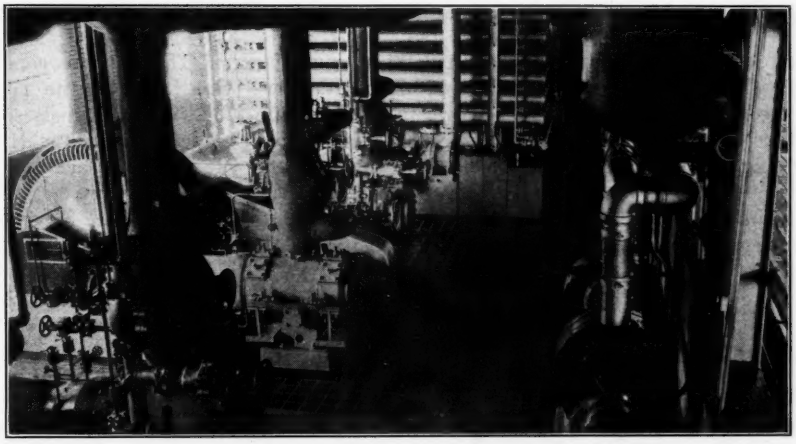


Fig. 6. General view of compressors, blowers and ammonia condenser. Each unit consists of horizontal duplex ammonia compressors, with the synchronous driving motors located to drive a compressor from each end of their shafts

Water Treatment

For making ice as well as condenser cooling purposes, city water is used. For ice making this is softened and filtered. The city main feeds directly into a small raw water tank, float controlled which in turn feeds into a large storage and treating tank. Water is softened by the use of alum and KWS No. 2. These chemicals are fed into the settling or storage tank in direct proportion to the amount of water entering. The sludge formed falls to the bottom of the settling tank which is drawn off at periodic intervals.

Softened water is delivered by gravity to two small filter pumps which force the water through either of two International Filter Co. sand filters into the can filling tanks. The filter pumps are small De Laval centrifugal machines each driven by one-hp. Linc Weld a.c. motors.

Filling tanks are provided for the purpose of providing just enough water exactly to fill one set of ice cans. At this plant, 25 cans are filled at a time on each of the two ice tanks. Each can filling tank is therefore provided with 25 compartments, each having an outlet with a curved nozzle for delivering the water into the cans. The amount of water delivered to these cans is controlled by a float valve so that there is no danger of the tanks overflowing.

Freezing and Harvesting

There are two freezing tanks, 103 ft. 8 in. long by 26 ft. 9¾ in. wide and 54 in. deep made of ¼-in. steel, each one holding 1150 cans, or a total of 2300 300-lb. cans in the two tanks. The cans are 11 by 22 by 51 in. deep and are made of No. 14 gage steel, with a ¼ by 1½-in. band. The Knickerbocker multiple can grid system is used. In this system, each can is suspended by a can band resting on a square bar running the full length of the wide side of the can. Each can is held firmly in place by four countersunk head rivets and any individual can can be slipped in or out of the grid without interfering with any other can.

A full row of 25 cans is harvested at one time. For

pulling and filling, two cranes are installed, one for each tank. These are 7-t. Euclid cranes with two Ideal Electric Co., 110-v. induction motors, one a 10-hp. motor for lifting and the other a 3-hp. unit for driving the crane.

Aerating System

An interesting feature of this plant is the aerating system, which is known as the Knickerbocker Mechanical Pendulum, low-pressure aerating system. This system features an air pressure of less than 2 lb. in combination with swinging drop pipes. A typical layout, showing the principle of operation, is shown in Fig. 4, while in Fig. 3 are shown details of the mechanism. The swinging drop pipes which suspend into the ice cans directly from the rocking lateral are connected to the air main, through a short length of rubber tubing. The rocking laterals connect to the rubber tube through a special automatic air valve and "EZ" connector as shown. The air valve, which is made of heavy brass with a bronze ball check, performs three functions—it makes a connection between the air main and lateral, it engages the moving rack to give a pendulum motion to the drop pipes and automatically opens the air supply when its two parts are slid together. The moving rack slides on rigid ball bearings and is driven through a system of connecting rods and eccentrics, by a one-hp. motor the speed of which is reduced by a speed reducer.

In operation, during the entire freezing process, the drop pipes swing slowly back and forth. This allows the pulling of an unusually small core and produces a clear and brilliant ice. The power required to do this is less than one horsepower for a 200-t. plant.

For supplying air to this system, two Tabco centrifugal blowers are provided. These are two stage units furnishing air at about 2 lb. pressure. They are driven by 25-hp. motors.

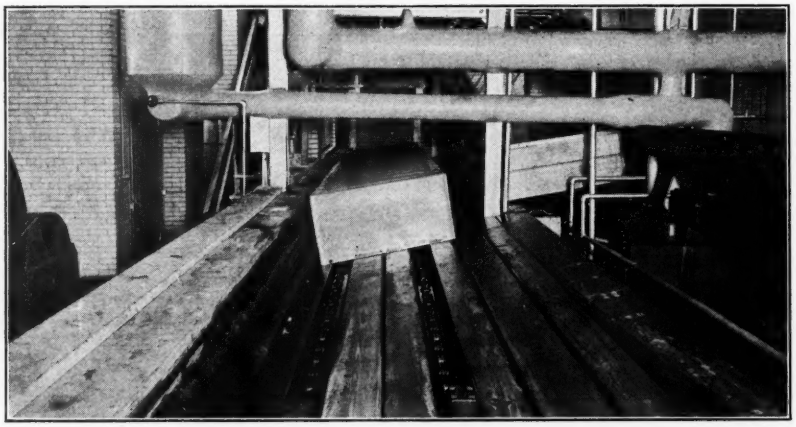


Fig. 7. Showing method of delivering ice from ice cans to the chain conveyors, for further delivery to the storage room. This view was taken in the Dorchester plant of the Boston Ice Co., but the arrangement at Cambridge is the same

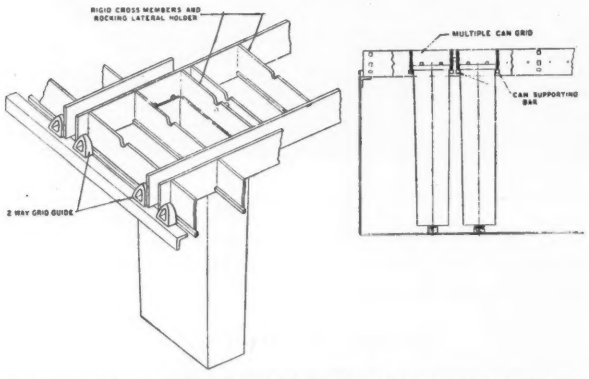


FIG. 8. GRID ASSEMBLY SHOWING 2 WAY GRID GUIDES WHICH INSURE EXACT POSITION OF GRIDS IN TANKS

The ammonia condenser used at the Cambridge plant is a De LaVergne, multipass unit, consisting of 45 8-in. by 18-ft. multipass shells, each shell containing 7 No. 9 gage galvanized steel tubes 2 in. in diameter. Of these 45 shells, 43 are used actually as condensers while the remaining two are used as ammonia liquid precoolers. The ammonia receiver is placed directly alongside the condenser and is built to withstand a pressure of 400 lb. It is 20 ft. long and 24 in. in diameter.

An interesting feature of the ammonia lines leaving the receiver is the venturi tube and manometer installed there. This equipment consists of a 2-in. by 1½-in. venturi tube together with a simplex manometer graduated in lb. per min. The equipment was built by the Simplex Valve and Meter Co. for anhydrous ammonia at 40 deg. F.

Water for Condensers

Two condenser pumps are installed, both DeLaval centrifugal units designed for operation under a 65-ft. head at 1750 r.p.m., one having a capacity of 1800 g.p.m. and the other 1000 g.p.m. The larger pump is driven by a 40-hp. Linc Weld motor and the smaller by a 25-hp. unit of the same make. These pumps pump the water to the top of the cooling tower located on the roof of the building. The cooling tower is 16½ ft. wide by 56 ft. long by 34½ ft. high and has a capacity of 1800 g.p.m. It is made entirely of redwood and was built by the Cooling Tower Co.

An automatic device regulates the amount of water in the cooling tower pan on the roof so that if the level in this pan falls below a certain safe level, city water is admitted until the safe level is again attained. This device consists of a diaphragm controlled valve installed on the city water line. The space above the diaphragm is connected to the cooling tower pan by means of a

½-in. line. This space also is provided with an outlet valve so that water coming down the ½-in. line from the cooling tower pan, continually passes out at the outlet. As long as there is water in the cooling tower pan, the flow continues and the water maintains a pressure on the diaphragm, keeping the valve in the city water line closed. Should the water in the cooling tower pan fall below a safe level however, the flow through the ½-in. line would be interrupted, relieving the pressure on the diaphragm and opening the city water valve.

Brine is cooled by means of four brine coolers each having 2250 sq. ft. of cooling surface, giving a total of 4500 sq. ft. per tank. Since each tank is rated at 100 t., this works out 45 sq. ft. cooling surface per ton of ice. These coolers are built similar to the condenser shells, being fitted with 2-in. tubes, and tested to 300 lb. Each cooler is fitted with an Arctic Liquid level gage, and has a 5-in. suction line. The liquid entering lines are 1 in.

Each freezing tank is provided with two brine agitators, one at each end. These are Helversen units fitted with 20-in. wheels and driven by 3-hp. General Electric induction motors.

Covering of Ammonia Lines

Particular care was taken in the covering of the ammonia lines. These were first wrapped with two layers of friction tape. Over this was then applied first, two layers of 1½-in. felt and then one layer of 1-in. felt with a layer of insulating paper between each two layers of felt. Next, two layers of friction tape were applied over the felt and this was painted with two coats of asphalt paint. A layer of rosin paper and an outer covering of 8-oz. canvas completed the covering. The two layers of friction tape between the felt and the rosin paper are of particular importance as they provide an absolute air seal around the whole covering.

Ice Handling and Storage

In harvesting, as stated previously, an entire row of 25 cans is pulled at one time. This row of 25 cans is conveyed by means of the crane to the end of the freezing room where it is lowered into the dip tanks so as to loosen the ice from the sides of the cans. Next, by means of the crane and by supporting one lower edge of the cans rigidly, the entire row is placed in an inclined position so that the cakes slide out of the cans onto the conveyor chains by gravity as shown in Fig. 7. This photograph was taken in the Dorchester plant of the Boston Ice Co. but the arrangement at Cambridge is similar.

The tank room conveyor, which is of the double chain type, moves an entire crop of twenty-five 300-lb. cakes at one time and delivers them, one by one, into the delivery room. The conveyor is reversible so that the crop from each tank can be delivered to the delivery room. This conveyor has a speed of 5 ft. per min. and is driven through a 212 to 1 speed reducer by a 4-hp. motor.

In the delivery room, two conveyors are installed. These, however, are of the single chain type, having speeds of 60 ft. per min.

Both of these are arranged to deliver the ice directly to the delivery platform or they may be used for storing.

Principal Equipment Installed in the Cambridge Plant of the Boston Ice Co.

GENERAL

Location of Plant.....Cambridge, Mass.
Owners.....Boston Ice Co.
Capacity.....200 t. daily
Number of cans.....2300
Size of cakes...11 by 22 by 42 in.—300 lb.
Compressor displacement per ton.....
.....12,164 cu. in.

EQUIPMENT

2 Horizontal, duplex, double-acting, 12 by 19½-in., 138-r.p.m., 100-t. ammonia compressors. Displacement per revolution, 17,643 cu. in. Total displacement at 138 r.p.m., 2,432,816 cu. in. De La-Vergne Machine Co.

2 Synchronous motors, 300-hp., 100 per cent p.f., 2300-v., 61.2-amp., 3-phase, 60-cycle with 7½-kw., 125-v., exciters. Electric Machinery Co.

1 Multipass type condenser consisting of 43—8 in. by 18 ft. multipass shells, each shell containing 7 No. 9 gage galvanized steel tubes, 2 in. dia. De LaVergne Machine Co.

1 Ammonia receiver, 20 ft. long, 24 in. dia., built for 400 lb.

1 1800-g.p.m., 65-ft. head, 1750-r.p.m., De-Laval ammonia condenser pump driven by

1 40-hp., 440-v., 47.5-amp., 3-phase, 60-cycle, "Linc Weld" motor.

1 1000-g.p.m., 65-ft. head, 1750-r.p.m. De Laval ammonia condenser pump driven by

1 25-hp., 440-v. Linc Weld motor.
Oil filters and reservoirs.....
.....S. F. Bowser and Co., Inc.

1 Simplex manometer and Venturi tube built for anhydrous ammonia 40 deg. F. Simplex Valve and Meter Co.

2 Tabco centrifugal blowers, size M-130, 2 stages, press., 2 lb. Allen and Billmyre Co.

1 driven by 25-hp., 440-v. Star Electric Motor Co. motor.

1 driven by 25-hp., 44-v. General Electric Co. motor.

4 Brine agitators, 20-in. wheels—Helversen (M & S) driven by

4 G. E. induction motors, 3-hp., 440-v., 1160-r.p.m.

1 Ammonia Purger, The Conner Purger Co.

1 Ammonia Distiller, 11 in. dia. by 66 in. high.

1 Water-oil separator, 20 in. dia. by 60 in. high.

4 Brine coolers—225-sq. ft. tubes, 2-in. No. 9 gage steel with 5-in. suction, 1-in. liquid line entering, 1¼-in. drain. De La Vergne Machine Co.

2 International water filters, 48 in. by 66 in. International Filter Co.

2 Filter pumps, centrifugal. De Laval Steam Turbine Co.

2 Linc Weld motors, 440-v., 2.2 amp., 3-phase, 60-cycle, 1800-r.p.m.

4 Chemical treating tubs.
2 Alum tubs 36 by 36-in.
1 KWS tub, 36 by 36-in.
1 Raw water tub, 36 by 36-in.

2 Sump pit pumps—De Laval Steam Turbine Co., driven by Linc Weld 1.5-hp., 440-v., 1800-r.p.m. motor.
Core pumps—Viking, Model ZL driven by
G.E. motor—3-hp. induction.

2 Freezing tanks, 1150 cans per tank; 46 rows, 25 cans per row. Knickerbocker Multiple can grids and cans.
Knickerbocker Stamping Co.
Tank covers, and brine cooler covers—American Ice Co.
Aerating system, Knickerbocker Mechanical Pendulum system, Knickerbocker Stamping Co.
Cooling tower—Atmospheric type, 16½ by 56 by 34½ ft., 1400-g.p.m. redwood. Cooling Tower Co.

2 Can filling tanks—27 in. wide, 30 in. deep by 26 ft. 4 in. long, 25 compartments in each tank. Vogt Machine Co.

CONVEYORS AND ICE HANDLING MACHINERY

1 Tank room conveyor—double chain, 53-ft., 10-in. centers, 5 ft. per min. Gifford-Wood Co. driven by 4-hp. General Electric Co. motor.

1 Delivery room conveyor, single chain, 46-ft. centers, 60-ft. per min. Gifford-Wood Co. driven by 5-hp. General Electric Co. motor through Philadelphia Gear Works speed reducer.

1 Delivery room conveyor, single chain, 74-ft. centers, 60-ft. per min. Gifford-Wood Co. driven by 3-hp. General Electric motor.
Benching machine, Master Stacker, driven by 2-hp., 110-v. Westinghouse motor, Lewis-Shepard Co.
Scoring machine, Perfection Ice Scoring Machine Co.

2 Euclid Cranes, 7-t. electric. Euclid Crane & Hoist Co.

3 37½-kv-a., 2300/440-v. single-phase transformers connected in delta for power service. Moloney Electric Co.

3 10-kv-a., 2300/220/110-v. transformers for lighting service, Moloney Electric Co.

MISCELLANEOUS

Boiler, locomotive type.....
.....James Russell Boiler Works
Heaters.....Thermal Unit Mfg. Co.
Piping Contractors.....P. S. Thorsen Co.

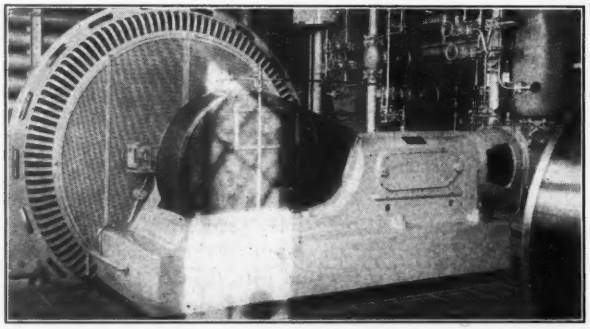


FIG. 9. ONE OF THE AMMONIA COMPRESSORS

The small one has a length of 46 ft.; the larger one, 44 ft. Attachments are fixed on 10-ft. centers.

The delivery room, as may be noted from the plan of the building shown in Fig. 2, is 81 ft., 4 in. in length by 73 ft. 7½ in. wide and has a floor area of 5982 sq. ft. The ceiling for benching is 6 ft. high.

For benching, a Lewis Shepard Co. master stacking machine is provided. This is driven by a Westinghouse 2-hp., 110-v. motor. A scoring machine is also installed, this being a Perfection machine operated by a 5-hp., 110-v. motor.

Heating Arrangement

For heating the building in cold weather, one coal fired James Russell Boiler Works locomotive economic type boiler is installed. The steam from this unit supplies 2 Thermal Unit Co. heaters, each rated at 3000 c.f.m. capacity and an air velocity of 1200 ft. per min. They are driven by 1/6-hp. motors.

Operation

The Cambridge plant was placed in service on August 3, 1928, and immediately began to exceed its designed capacity of 200 t. daily.

While there are many things which must be straightened out after the plant is put in operation before the final efficiency can be reached, the figures for the first full month's operation or for the month of September, 1928, were as follows:

Average production.....210.6 t. of ice per day
Average head pressure..... 135 lb.
Suction pressure .....22.6 lb.

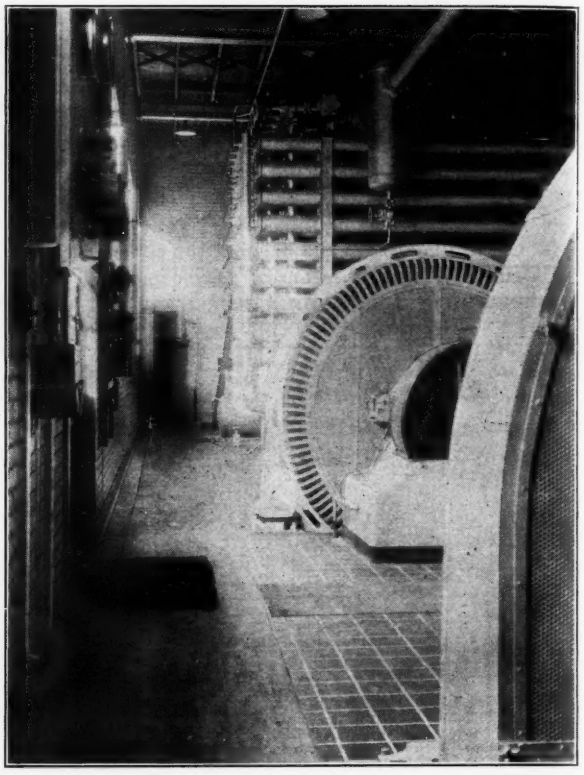


FIG. 10. ANOTHER VIEW SHOWING COMPRESSORS AND CONDENSERS

Temperature of water coming on ammonia condensers ..... 67½ deg.
Off ..... 75 deg.
Average tank temperature..... 12½ deg.
Average kw-hr. per ton of ice made including all auxiliaries and ice handling machinery..... 43

During the summer months, the liquid temperature is brought down to between 50 and 60 deg. by using water from dip tank sump pit for liquid cooler.

The plant was designed by the engineering department of American Ice Co. in New York City.

In concluding, we wish to acknowledge our indebtedness to Rudolph Sommers of the Boston Ice Co. for courtesies extended and for supplying information and data on which this article is based.

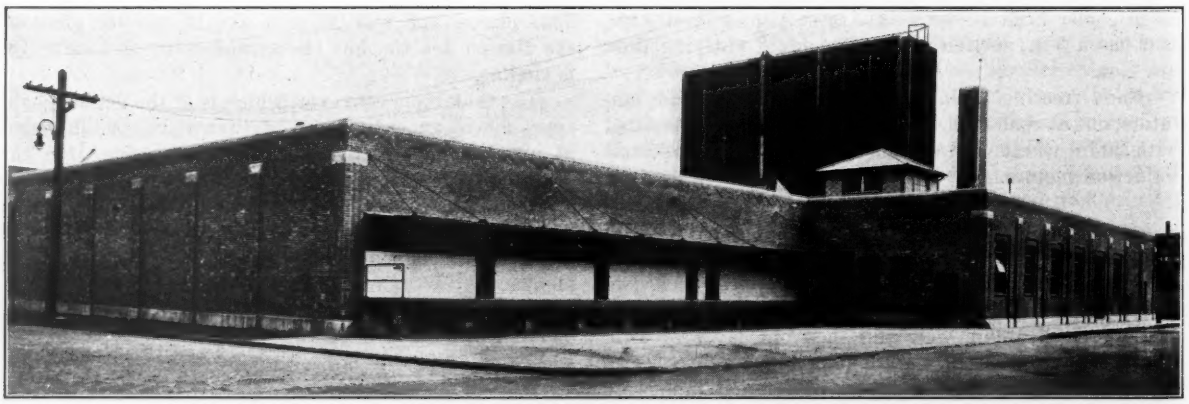


FIG. 11. VIEW OF THE CAMBRIDGE PLANT SHOWING THE DELIVERY PLATFORM

Essentials of a Heat Factory*

Easy Operation, Flexibility, Ample Volume, Well-Mixed Gases Needed for Efficiency and Output. By A. A. Potter† and H. L. Solberg††

FOR FUEL BURNING, a system should provide for feeding the fuel in proportion to the demand for heat, for supplying air in proportion to the fuel, for heating the mixture of combustible and air to a temperature above the ignition temperature (700-1200 deg. F.) and maintaining it at such a temperature until combustion is complete and for disposal of any incombustible residue.

To be successful a fuel burning system must fulfill the following requirements:

(1) Combustible constituents of the fuel must be thoroughly mixed with sufficient oxygen to complete their combustion. Too much excess air increases the loss of heat carried away by the hot flue gases which leave the boiler. An insufficient supply of air or poor mixing results in the escape of combustible gases and a loss due to undeveloped heat.

(2) Air and combustible material must be heated to a temperature above the ignition temperature of the fuel before combustion can take place. In general, the higher the furnace temperature, the faster will be the rate of ignition of the fuel, the greater will be the velocity of chemical reactions and the higher will be the boiler efficiency and capacity.

(3) Sufficient space and time must be provided for completion of the combustion processes before the gases are permitted to strike the relatively cool heat-absorbing surfaces, which will cool them to a temperature below the ignition temperature.

(4) To maintain a reasonably constant boiler pressure, the supply of fuel and air as well as the rate of combustion must be so controlled that the quantity of heat produced is equal to the demand for heat.

(5) Ash and refuse must be removed in such a manner as to avoid interfering with continuous and efficient operation.

(6) The installation must have sufficient flexibility and capacity to handle reasonable fluctuations in the demand for steam, to carry the maximum load easily and to operate at high efficiency on normal loads.

(7) Design of the system should be for the maximum efficiency, consistent with reasonable first cost and low maintenance. It is poor practice to spend more money on refinements than will be warranted by the higher efficiency obtainable.

(8) Most important of all, any fuel burning system must be reliable.

Fuel Burning and Fuel Absorbing Equipment

Primarily the function of the fuel burning system is to convert the chemical energy of the fuel into heat. The function of the boiler, superheater and other heat-absorbing surfaces, is to absorb this heat with the highest possible efficiency. Functions of the fuel burning and heat-absorbing equipment are, however, closely related, especially with the growing tendency to build the boiler around the fuel burning equipment. The position and extent of heat-absorbing surfaces affect the temperature of the fuel bed and combustion space, also the rate and completeness of combustion. The fuel bed and furnace temperatures and the amount of excess air affect the efficiency and capacity of the heat-absorbing surfaces. Consequently, the fuel burning and heat-absorbing equipment should be designed as a unit and their performance must be judged as a unit.

Methods of Burning Fuels

Fuels in gaseous, liquid or pulverized form may be burned in suspension as they float through the atmosphere in the combustion chamber or furnace, or, if solid, they may be supported on a grate.

Gaseous fuels require a burner capable of mixing the gas with the air necessary for its combustion; also a furnace maintained at a high temperature and of such size and shape that combustion may be reasonably complete before the gases strike the cold heat-absorbing surfaces. For liquid fuels, the burner is designed so that the fuel is introduced into the furnace in an atomized condition, where it burns like a gaseous fuel. Pulverized fuel, reduced in a preparation plant to a fine dust is introduced into a high temperature furnace through a suitable burner and burns, as it floats through the furnace, in a manner similar to gas or atomized oil but at a slower rate, because of the larger size of the individual particles.

All solid fuels, except when pulverized, are supported during the combustion process on a metal grate through which air is admitted, the fuel being supplied to the grate by mechanical means or by hand. Volatile combustible gases which are distilled from the fuel are burned partly in the fuel bed but mainly in the combustion chamber above the fuel bed. The fixed carbon which remains on the grate is burned to CO and CO_2 by the air supplied through the grate and any CO leaving the surface of the fuel bed can be burned to CO_2 in the combustion chamber by supplying the necessary air.

Furnace Volumes

Included in the furnace or combustion chamber is the space enclosed within the walls of the setting, the grate, floor or water screen and the point of entrance of the gases into the bank of boiler tubes. The entire combustion process involved in burning liquid, gaseous and pulverized fuels takes place in the furnace.

When coal is burned on grates, the potential heat in the combustible gases leaving the fuel bed may be as much as 60 per cent of the heating value of the fuel. The function of the furnace is to effect reasonably complete combustion of these gases with minimum excess air before they strike the relatively cold boiler tubes. If this is not done, there will be secondary or delayed combustion among the boiler tubes, resulting

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†Dean of Engineering, Purdue University.
††Assistant Professor of Mechanical Engineering, Purdue University.

in high flue gas temperatures and decreased efficiency; or else the gases will be cooled below the ignition temperature (about 1200 deg. F.) and escape unburned.

These Are Essential

Important factors, which determine the size of furnace required for reasonably complete combustion, are (1) per cent of excess air, (2) turbulence, (3) kind of fuel, (4) type of stoker or burner, (5) rate of combustion, (6) temperature of incoming air, (7) fusing temperature of the ash and (8) position and extent of radiant heat-absorbing surfaces.

How Much Air?

Percentage of excess air present in a furnace has an important bearing on the completeness of combustion.

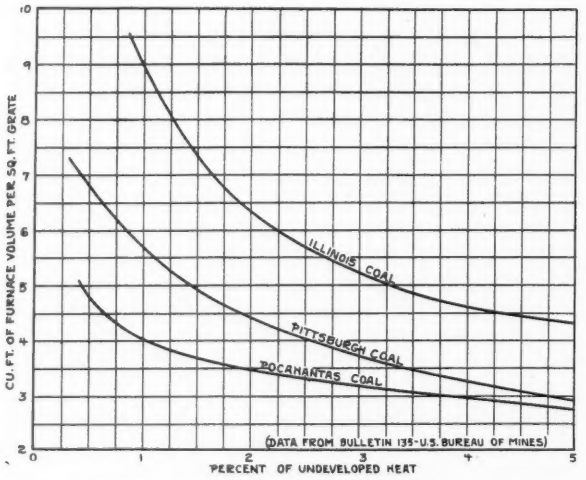

CU. FT. OF FURNACE VOLUME PER SQ. FT. GRATE
PERCENT OF UNDEVELOPED HEAT
ILLINOIS COAL
PITTSBURGH COAL
POCAHANTAS COAL
(DATA FROM BULLETIN 135-U.S. BUREAU OF MINES)

FIG. 1. FURNACE VOLUMES FOR BURNING 50 LB. PER SQ. FT. OF GRATE PER HR. OF ILLINOIS COAL

The chance that each molecule of combustible gas will find the oxygen necessary for its combustion increases with the number of molecules of free oxygen present. Consequently, small furnaces and smoke producing furnaces can often be operated so as to effect reasonably complete combustion by increasing the excess air present in the furnace. Such a practice increases, however, the loss due to sensible heat carried away in the chimney gases and is likely to decrease the overall efficiency.

Plenty of Furnace Volume

High efficiency is obtainable only with low stack losses; this requires that the fuel be burned with a minimum quantity of excess air. Large furnaces are necessary in order to lengthen the time during which the combustible gases are in the furnace and thereby increase the probability that they will find the necessary oxygen. Figure 1 shows the effect of excess air upon the furnace volume required by Illinois coal when burned with a loss due to incomplete combustion of 1, 3 and 5 per cent of the heating value of the fuel. Many pulverized fuel furnaces are operated with 20 per cent of excess air, while stoker fired furnaces are supplied with 25 to 50 per cent of excess air. Large and expensive furnaces are required under these circumstances, if the loss of heat due to incomplete combustion is to be maintained below one per cent.

Turbulence within the furnace is another factor which determines the size of furnace required for reasonably complete combustion. At ordinary furnace temperatures, the velocity of chemical reaction is so great that the limiting factor is the ability to bring the oxygen into contact with the molecules of combustible gas, or the particles of atomized oil or pulverized coal, and to remove the dead products of combustion from their surfaces. Turbulence or thorough mixing of the furnace gases is, therefore, essential if complete combustion is to be effected in a small furnace. In many large furnaces now in use, in which the cross-sectional area is several hundred square feet, poor mixing and pronounced stratification occur so that in part of the furnace the gases are rich in hydro-carbon compounds while, at other points, large quantities of excess air are present.

Obviously, the remedy in such a situation is to give more attention to the problem of bringing the oxygen into contact with the combustible gases rather than to increase the size of a furnace, which is already large and expensive. Proper location of mixing arches, the injection of over-fire air in stoker installations and the use of turbulent burners for oil, gas and pulverized coal will promote better mixing of the furnace gases, thus reducing the size of furnace required for the good combustion of a given quantity of fuel.

Furnace Volume Depends on Kind of Fuel

Type of fuel is of considerable importance in determining the size of the furnace. Oil and gas can be burned in smaller furnaces than pulverized coal because the smaller sizes of the individual particles of fuel make it possible to burn them in a shorter period of time. When coal is burned on stokers, the amount of volatile matter to be burned above the fuel bed varies with the per cent of volatile matter in the coal. It is for this reason that high-volatile coals require larger furnaces than hard coal. Considerable furnace volume is required, however, even for anthracite coal because of the large quantity of CO leaving the fuel bed.

Quality as well as quantity of volatile matter is of importance. The difficulty of burning hydrocarbon compounds increases with the carbon content of the gases and vapors. Experiments by the U. S. Bureau of Mines (Bulletin 135) indicate that a measure of the quality or ease of burning of volatile matter is indicated by the factor:

$$\frac{\text{volatile carbon}}{\text{available hydrogen}} \quad \text{or} \quad \frac{\text{total carbon minus fixed carbon}}{\text{total hydrogen minus (total oxygen} \div 8)}$$

Of two coals having the same per cent of volatile matter, the one in which this factor is the greater will be the harder to burn.

Bureau of Mines experiments also indicate that the furnace volumes required to burn coals of different kinds with the same completeness of combustion and under the same condition, are proportional to the following factor:

$$(\text{per cent of volatile matter in moisture and ash free coal}) \times (\text{volatile carbon} \div \text{available hydrogen})$$

For three typical coals, the effect of the composition of coal upon the furnace volume required for its combustion is shown in Fig. 2. Horizontal values show

per cent of undeveloped heat, or the heating value of the unburned gases in the furnace, expressed in per cent of the heating value of the fuel. For the same completeness of combustion, Illinois coal requires from 1½ to 2 times the furnace volume required by Pocahontas coal.

Air Supply and Rate of Heating Affect Volatile Gases

Rate of heating of the fuel and the presence or absence of air during the heating process have an important bearing upon the amount and quality of the volatile gases distilled from coal and are dependent upon the design of the stoker or the method of operating a hand-fired grate. Coal which is heated quickly produces large quantities of heavy hydrocarbon compounds, such as tars, which are complex in molecular structure and unstable. In the absence of the air necessary for their combustion, they quickly decompose at high furnace temperatures into carbon or soot and lighter hydrocarbons.

Carbon so formed is difficult to burn, even in a large furnace supplied with plenty of air and produces the black color in chimney gases, commonly called "smoke."

If the same fuel is heated slowly, less carbon will be given off as volatile matter and the hydrogen content of the hydrocarbon compounds will be correspondingly higher. The molecular structure of these hydrocarbons will be simpler and more stable; they can be burned more easily and will not decompose as readily to form soot or smoke. Furthermore, if air is supplied to these gases as they are being produced, they can be quickly and easily burned, thereby reducing the size of the furnace required for their combustion.

Volume Not Proportional to Combustion Rate

In burning coal on a grate or stoker, the furnace volume required for good combustion does not increase in direct proportion to the rate of combustion. The Bureau of Mines experiments (Bulletin 135) indicate that, with 75 per cent excess air, increasing the combustion rate from 25 lb. per sq. ft. of grate per hour to 50 lb. required an increase in furnace volume of only 20 per cent and, with 25 per cent of excess air, an increase of only 50 per cent in order to burn the fuel to the same completeness of combustion in each case.

Initial temperature of the air supplied for combustion has an important bearing upon the furnace volume, particularly in the case of pulverized coal, oil and gas. Combustion can begin only after the air is heated to the ignition temperature of the fuel. The use of preheated air for combustion reduces the time required for this process and materially shortens the flame.

Factors Limiting Furnace Capacity

High capacity and continuity of operation with reasonable maintenance costs are required of a successful furnace, particularly in central station practice where load fluctuations are violent. Frequently, the size of the furnace is such as to impose a limit on the capacity obtainable from a boiler. This is particularly true when burning a coal having an ash of low fusing temperature, especially where the furnace is not adequately cooled by radiant-heat-absorbing surfaces. Under such circumstances, at high rates of combustion, the furnace temperature is so high that the ash in suspension in the furnace is in a molten state and, upon impinging on the brick walls, will literally wash them away.

This trouble is aggravated in pulverized coal furnaces because all of the ash is in suspension in the furnace. One remedy for the trouble has been the use of larger furnaces with the walls set back so that less ash impinges on them. Reducing the furnace temperature by means of excess air, air cooling of the brick walls, or the use of water and steam-cooled surfaces are other methods of reducing the trouble. This problem is of such importance that it will be discussed more fully in a subsequent article.

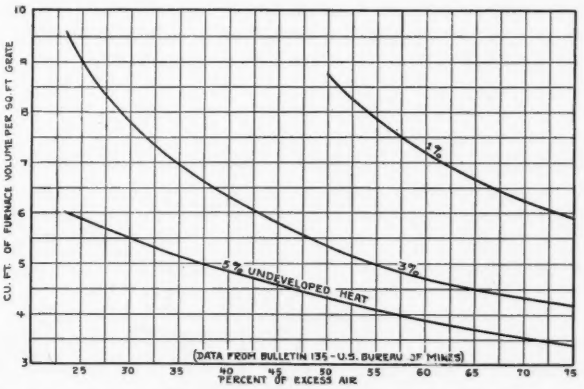


FIG. 2. FURNACE VOLUME NEEDED FOR COMBUSTION OF 50 LB. PER SQ. FT. OF GRATE PER HR.

In general, it may be said that the determination of the correct size and shape of furnace is a problem which involves so many variables that it must be solved separately from each individual installation. Upon the correctness of the solution depends the success of the installation. Failure to install a properly designed furnace may result in poor efficiency, excessive maintenance, reduced capacity and increased installation cost per unit of effective capacity.

Puget Sound Power & Light Co., Seattle, Wash., has arranged a 1929 expansion and improvement program to cost about $9,000,000 and will proceed with work at once. The primary features of the development include the completion of first unit of new steam-electric generating plant at Renton, known as the Shuffleton Station, with capacity of 35,000 kw., to be completed next fall; approximately $5,000,000, of gross amounted noted will be used for this development. A fund of $225,000 will be utilized for extensions and betterments at the Electron plant, with installation of a 7500-kw. generating unit to replace a 5,000-kw. machine, damaged by fire last year; about $300,000 will be used for extensions and improvements at other generating plants. Other work is as follows: Extensions in transmission lines, $1,400,000; additions to power substations and switching stations, $400,000; improvements and extension in overhead distributing lines, $717,000; extensions and betterments in underground distributing system at Seattle, $130,000. The remainder of the fund will be used for miscellaneous work. The company is under the direction of Stone & Webster, Inc., Boston, Mass.

U. S. Shipping Board Conducts Tests on New Pulverized Coal Equipment for Marine Service

OFFICIAL TESTS by the U. S. Shipping Board are rapidly being brought to a conclusion on a new design of pulverized coal apparatus at the Fuel Oil Testing Plant of the League Island Navy Yard, Philadelphia, Pa., demonstrating application of individual pulverizing mills and burners to the furnaces of a Scotch marine boiler. Although at this writing the results of the official tests have not been announced, preliminary calculations indicate heat release of upwards of 100,000 B.t.u. per cu. ft. per hr., considering only the primary combustion space, and overall efficiencies ranging between 75 and 80 per cent.

This new equipment is primarily designed for burning pulverized coal in the furnaces of Scotch marine boilers since it is generally conceded in marine practice that this is the most difficult condition to meet. As it had been previously demonstrated that use of pulverized coal on board ship is successful, the maker of the equipment aimed to develop a machine that would be compact and rugged and that would have universal application, whether the present fuel was oil or coal on the grate.

Pulverizer and Boiler Arrangement

Such equipment, shown in Fig. 1, consists of a burner, a motor or turbine-driven impact pulverizing mill with two stages of pulverization and containing a fan to furnish primary or carrying air and feeding apparatus to regulate the amount of coal going into the mill. As shown, this equipment is all assembled as virtually a single unit, to be installed on the boiler front serving each furnace. Pulverizing mills are built for these units by Erie City Iron Works.

In the test installation, a Scotch marine boiler of 2555 sq. ft. of heating surface is used, having three furnaces each approximately 3 ft. 8 in. in diameter and 8 ft. long. At the rear of each furnace is a combustion chamber approximately 4 ft. wide, 2 ft. 6 in. long and 7 ft. high, the furnace volume being 66.3 cu. ft. and a combustion chamber volume of 90.2 ft. in each furnace or a total volume of 156.5 cu. ft. per furnace.

This boiler was equipped with the standard Howden forced draft front, as used in marine practice, and only minor changes were made in this, as the pulverized coal equipment was designed for such fronts.

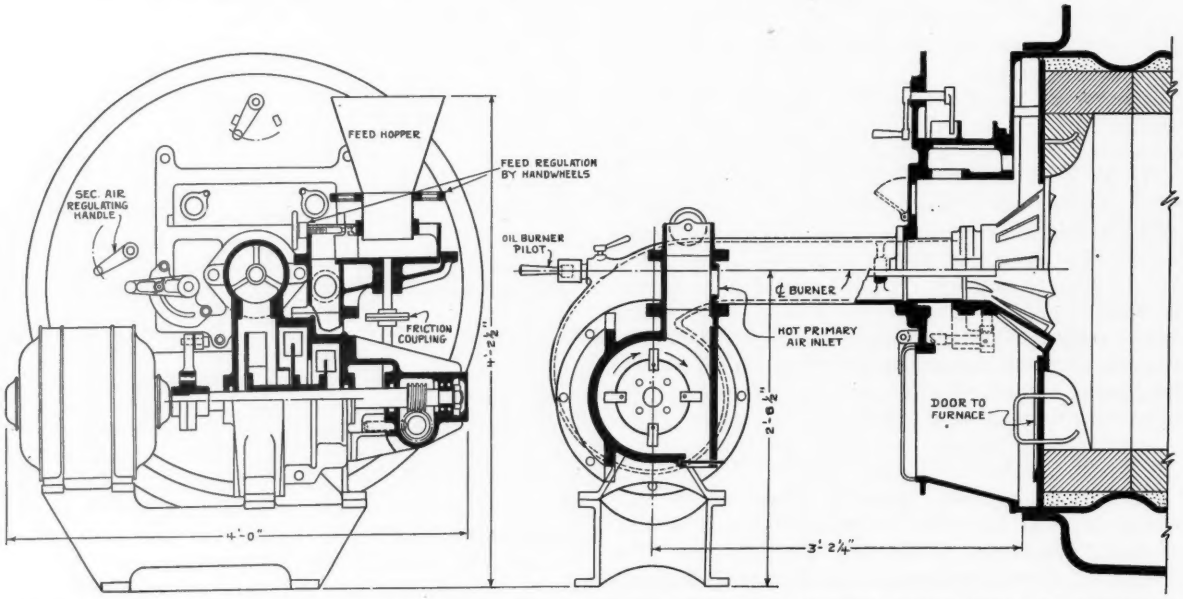


FIG. 1. CROSS-SECTION OF EQUIPMENT, SHOWING FINAL DESIGN IN WHICH AXIS OF ROTOR WILL BE PARALLEL TO BOILER FRONT

Arrangement of Pulverizer

In the original arrangement of units, each of the mills was set with its shaft perpendicular to the boiler front, Fig. 2, the fan taking coal from the second pulverizing stage through its center and discharging to the burner along the center line. The driving shaft was hollow and an oil burner about 6 ft. long was inserted into the burner for ignition.

The arrangement shown in Fig. 1, however, is to be adopted, as it is expected to permit use of a shorter oil burner, to give better fan efficiency and to permit driving all three pulverizers by one motor or turbine, by mounting their rotors on one shaft extending across the boiler front and parallel to it, the driving unit being between two of the pulverizers or at the end, as desired. Such a rearrangement will also permit better feeder operation. The pulverizers are designed to operate at approximately 3600 r.p.m.

As shown, the furnaces are lined with refractory for

a distance of 27 in. from the front. Primary air is supplied by the pulverizer exhauster fan; this primary air is preheated air from the Howden front, brought by a 3-in. pipe to the first pulverizing stage. Secondary air, which is also preheated to approximately 200 deg. by the Howden front, enters the burner through the registers.

Coal and Air Supply

Raw coal enters the hopper of the pulverizer feeder, falls onto the revolving plate, which is driven from the pulverizer shaft through a worm gear and a friction clutch. Coal is scraped off the plate by a plow, to provide constant feed for the first stage. After pulverization, the fan blows it direct to the burner, where it is spread by a cone having spiral vanes to whirl the coal stream and to produce a short turbulent flame.

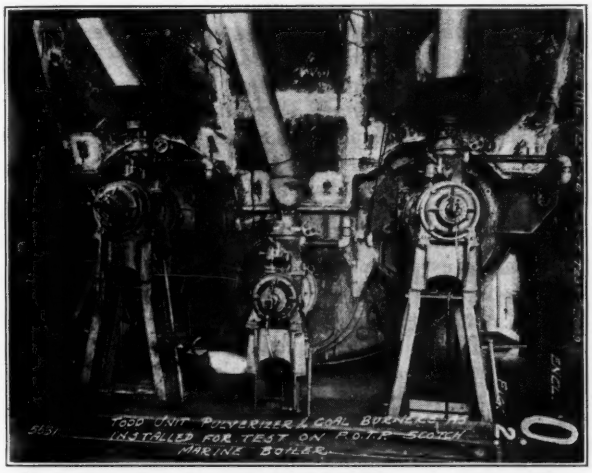


FIG. 2. UNIT PULVERIZERS AND BURNERS AS ORIGINALLY INSTALLED FOR TESTING

Secondary air entering through the registers, surrounds this stream of coal and primary air and is swirled into it as it leaves the burner and ignites. About 25 per cent of the total air used for combustion is supplied as primary air and the remainder as secondary air. Each pulverizer has a capacity of from 200 to 750 lb. of coal an hour and in the test installation each unit is driven by a 10-hp. squirrel-cage motor.

Tramp iron entering with the coal is discharged by centrifugal force at the bottom of the first pulverizing stage and is removed through a door in the pulverizer case.

Fineness of Pulverization

On a recent test run, using 300 lb. of coal an hour per burner, the following pulverization was obtained of a coal of about 13,800 B.t.u. 28 per cent volatile, 60 per cent carbon and 10 per cent ash, containing 3.4 per cent moisture as fired.

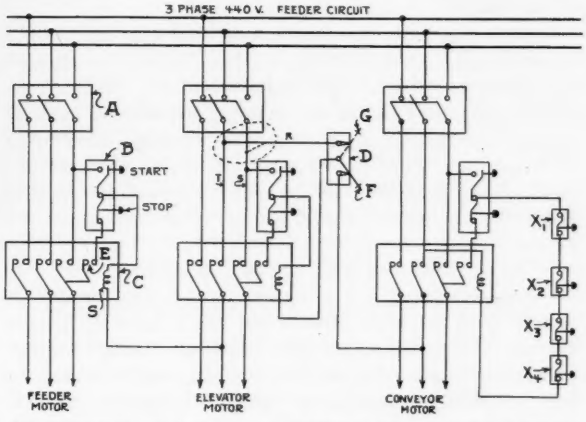
	Wt. left on screen %	Through screen %
On 50 passing 40	0.5	100
" 70 " 50	0.1	99.9
" 100 " 70	0.1	99.9
" 140 " 100	0.4	99.5
" 200 " 140	1.1	98.7
" 300 " 200	3.2	96.5

Tests on the above-mentioned equipment have been made by the U. S. Navy and U. S. Shipping Board after experiments made by its manufacturer, the Todd Dry Dock Engineering & Repair Corp. of New York, over a period of two years. Many different tyes of burners were used as well as various applications of primary and secondary air. The equipment is designed for adaptation to any type of boiler or bunker construction on board ship without making any alterations. Only those changes are necessary in the Howden front that are usually made when changing from coal to oil; secondary air is used at the same pressure as when burning coal on grates and this permits use of the ducts and fans that are already installed in the ship.

It is stated that an 8800 dead-weight-ton cargo steamship is to be equipped with the new pulverized coal equipment and will use it on a long voyage in the near future.

Interlocking Coal Handling Equipment

Our attention has been directed to a slight error in the diagram, Fig. 2, on page 294 of the March 1 issue in Mr. Von Dannenberg's article on interlocking coal handling equipment. In this diagram, the line R is



CORRECTED DIAGRAM OF WIRING FOR INTERLOCKING COAL HANDLING SYSTEM

shown connected to the line S, as shown by the dotted line in the dotted circle on the accompanying diagram. This line should have been shown connected to the line T, as indicated by the full line.

As reported to the Department of Commerce by the 10 leading manufacturers in the industry, sales of mechanical stokers in February, 1929, totaled 80 stokers under 31,554 b.hp., as compared with 97 stokers under 42,392 b.hp. in January and 85 under 43,643 hp. in February, 1928. Of the total of 80 stokers sold in February, 1929, 26 were installed under fire tube boilers of 3933 hp. capacity and 54 under water tube boilers of 27,621 hp. capacity.

Each standard ammonia tank contains from 100 to 110 lb. of ammonia and each tank should be carefully weighed before and after emptying.

Boiler Operation Improved by Mixed Fuels

COAL PURCHASING METHODS OFTEN RESPONSIBLE FOR LOW EFFICIENCY. QUALITY OF FUEL MAY BE ADAPTED TO FURNACE BY MIXING COAL AND COKE. BY R. C. DEMARY*

HIGHEST POWER PLANT efficiencies today are maintained in practice in the plants owned and operated by the public utilities where approximately 40 million tons of coal are burned yearly. These efficiencies run extremely high in such plants, over long periods of time and not just for a few hours.

Seventy per cent of the cost of producing light and power is fuel and the owners of the plants could well afford far better talent and instruments that would assist in cutting down fuel costs.

Let us first consider where and how we purchase our fuel.

1—Does a personal friend govern our supply?

2—Is coal bought that has the lowest first cost?

3—Is coal bought that has the highest first cost?

4—Is so little importance attached to the fuel problem that it is bought carelessly?

5—Is coal bought for reciprocal trade reasons?

6—Like a bargain hunter is "distress" coal the base of the supply?

Of course, as a rule, the lowest first cost coal is the lowest in quality and unless we have high-class trained operators we will not get value received. When low-grade fuels are used all the evils of combustion such as smoke, soot, high ash, corrosion of stacks, interrupted service and a multitude of other minor ills are encountered. Therefore the use of a cheap low-grade coal is justified only where special preparations are made for its use.

Highest first cost coal will not necessarily give you the cheapest steam. The excessive cost may be due to certain qualities which would not affect your plant conditions. It may be extremely low in volatile matter, making it more suitable for domestic use. It may be high in volatile, making it valuable for gas or it may have a high hydrogen content making valuable for by-product purposes or a long freight haul may be the reason for the high cost.

LACK OF INTEREST IN PURCHASING COAL

You may not appreciate the realitive merits of one coal over another. You may look upon your boiler room as a necessary evil and an uninteresting, dirty part of the plant. If so, the chances are you are careless in the purchase of your fuel and are not interested in getting a dollar's worth of heat out of every dollar's worth of coal burned.

Often the coal is purchased from a "friend" or for reciprocal trade reasons with no thought as to quality. The worst problems with which we have to deal are the so-called "distress" coal problems. We always have with us men who are looking for bargains. They are known to the coal trade and easily fall victims to the "distressed" coal story. They tell of some jobber who has a few carloads of good coal remaining unsold and which he is willing to sacrifice to save demurrage. Usually this coal has been shunted about the country unable to find a purchaser and when sold the buyer is more distressed than the coal.

Coal also comes to us camouflaged with fancy names which mean nothing.

Many buyers of large quantities of coal use the B.t.u. basis which works out especially well where there is coöperation between the engineer and the purchasing agent. In buying on the B.t.u. basis, however, one serious drawback is encountered, that is the difficulty in securing samples of the coal which are representative of the total delivered. It would hardly pay for the small or medium-sized plant to go to the trouble and expense of purchasing on the B.t.u. basis but these should buy their coal on results obtained by comparative tests. No two plants are alike and a coal that gives satisfaction in one plant may give only trouble in another.

Quite often a coal having a lower heat value will liberate more available heat than a coal having a much higher heat content.

Almost any coal may be burned efficiently if proper conditions are created. This may mean resetting the boilers, installing stokers, building a new stack, providing coal crushers or forced draft.

It is seldom practicable to make radical changes in power plant equipment for the purpose of adapting it to another fuel. It is then apparent that the fuel changes are restricted to those whose characteristics permit them to perform with highest efficiency in the plant with its present equipment and operating conditions.

SELECT FUEL TO SUIT FURNACE

When we consider the true value of coal we must take into consideration the style of furnace, draft, amount of ash and sulphur, clinker and the type of labor available. The experience of the plant engineer is the best guide in determining the cheapest fuel for any particular plant and the owner who is wise will not fail to consult him. If this were done more often, the average isolated plant would show some remarkable reductions in the cost of power production.

After we have decided on the coal best adapted to our plant, we must see that we are getting out of it all there is to be had.

In the small and medium-sized plants where the efficiency is always the lowest, we find our chief fuel losses due to excess air—air taken into the furnace in excess of the amount required for complete combustion. This air must be heated to the temperature of the exit gases and all the heat carried by it to the chimney represents waste. This excess air can be greatly reduced by checking the settings and seeing that they are tight, and that there are no air leaks about the firing doors and other furnace openings. There are other wastes which are undesirable and which should be taken into consideration.

Coal is wasted between the coal pile and the furnace and in the boiler room before being burned. This waste,

*Combustion Engineer for City of Akron, Ohio.

while not so large, is more or less important and there is no excuse for it. A ton of coal at the mine will have a loss of one per cent charged to waste and weather and another one per cent in careless handling at the destination. We start out, therefore, with a handicap of two per cent which we think is small and hardly worth bothering about, but when we consider that in many cases, only 2 per cent of the total energy contained in the fuel reaches the machines, that 2 per cent looks mighty big.

If our fireman is careless, there will be considerable loss in the ashes due to combustible material falling through the grates though our grates and fuel are adapted to each other.

Let us check our grate surface. It may be too large or too small and if so our loss will be serious. Too much grate surface will make it difficult for the fireman to keep it properly covered. The fires will be thin and a great amount of excess air will flow in through the grates. If the grates are kept properly covered, there will be too much steam and we shall have a loss through the safety valve. The fireman can do much in this case by proper regulation of the damper, but a far better way would be to cover a part of the grate surface with ashes or bricks and thus reduce the area.

Combustion Rate Is Important Factor

Twenty pounds of the average bituminous coal, per hour per square foot of grate surface, may be taken as about right, in the average hand-fired plant using natural draft. A slower rate of combustion usually means thin fires and excess air. A higher rate will cause the fireman to use the slice bar which will not only cause excess air but a waste of combustible in the ash pit. When the grate surface is out of proportion, the fireman can do much to maintain efficiency if he understands his business and the waste can be excessive, through ignorance and carelessness, even where the grate surface is right. The draft might be right and the fires wrong or the fires right and the draft wrong. We come right back to the fireman, the biggest problem in the plant. Our check may show faults in the furnace. The setting may be so low or the air leaks so great as to cause incomplete combustion or make it impossible to maintain the fires in proper condition. Certainly we should not be so unjust as to hold the fireman responsible for conditions beyond his control.

We must have rapid water circulation if we would have rapid heat absorption and here again enters another problem. In the smaller sized plants proper attention is rarely given to the cleaning of the boiler surfaces.

An almost unbelievable number of plants of from 50 hp. to 250 hp. exist where the flues are cleaned sometimes once a week and sometimes only once a month and occasionally a plant is found that has been in operation for over six months and the flues never cleaned.

If we keep our heating surfaces clean, both inside and outside and our draft regulated so that the gases will leave the heating surfaces at the lowest possible temperature, we have done about all we can with the boiler itself to insure efficiency.

Brickwork around a boiler is used to keep the heat in and the cold out. In the average plant, the loss due to the inflow of cold air is greatly in excess of the loss of heat through the setting. These leakages through the setting may be almost entirely eliminated by sealing the cracks or better still by covering the entire setting with an efficient plastic compound. The cost is small and the returns on the investment are bound to be large.

Flame or fire is a chemical reaction or combination generally known as combustion. When this flame comes into contact with the cold air leaking in around the setting and with the cold shell of the boiler, combustion is retarded and in many cases entirely stopped. I mention "cold" shell. If your boiler is clean as it should be, the temperature of the plates or metal will not be much over 10 deg. F. above the temperature of the water on the inside. If we are carrying 100 lb. steam pressure, our water temperature will be approximately 327 deg. F. and the temperature of the boiler heating surfaces about 340 deg. F. which is certainly cold when compared with the high temperature of the flame and gases.

When we retard combustion, we produce smoke and soot and also permit other valuable gases which are combustible to escape without liberating the heat they are capable of doing. Soot has a high insulating value, higher than asbestos and certainly any engineer who covered the heating surfaces of his boiler with a good thick coating of asbestos would be severely criticized and probably lose his job in the bargain.

This soot loss should be charged to the furnace because, if the furnace is of the proper size and design, it can be so operated that the flame will not come into contact with the metal surfaces until after combustion has been practically completed. Remember the boiler should receive nothing but the hot gases which result from complete combustion together with such air as is necessary for the burning of the fuel.

Volatile Reduced by Mixing Coal and Coke

In the greater number of our smaller plants where horizontal return tubular boilers are installed, we shall find low settings, which certainly are not conducive to efficiency. If our setting is low, the distance from grate to shell should not be less than 36 in. We might do well to use a mixture of coal and coke.

In a great many cases, this mixture has been tried out and with some excellent results. The best results will be obtained when nut or slack bituminous coal is used and mixed with an equal part of coke (by bulk). A much lower draft can be maintained, boiler heating surfaces are kept cleaner, due to less soot, and a large percentage of smoke is eliminated. While the coal we are using may be high in volatile matter, this blending of the fuels reduces this percentage.

Coke does not have the chilling effect on the fire that green coal does when fired alone and, being almost free from hydrogen, burns without the formation of water. Coke also prevents the slack from caking, quickly becomes incandescent and aids in burning the volatile distilled from the coal which otherwise might be lost.

While the cost of coke is considerably more than that of coal, the plants where it has been tried out claim that the mixture is so much more efficient that the additional cost is more than offset by the increase in efficiency. In each plant the mixture should be varied to

give best results. The proximate analysis of the mixture can be made to resemble that of the most efficient coals and is capable of infinite variations to suit conditions. It would be best to start with the mixture mentioned and vary the quantity of coke, watching the results until the correct ratio is determined.

Many engineers have no aversion to large boiler units but are opposed to working their boilers above rated capacity, believing it unsafe to do so. This opposition is largely due to the practice of assigning 10 sq. ft. of heating surface to a boiler horsepower. The capacity of a boiler is just what you can get out of it. They should be rated at their most efficient capacity and not by dividing an arbitrary amount of heating surface into the total heating surface.

In a few words, the proper coal to use or purchase is that which makes steam most economically. The only place to determine that is in the plant and under regular operating conditions.

Combination Air Preheater and Economizer Developed by British Engineer

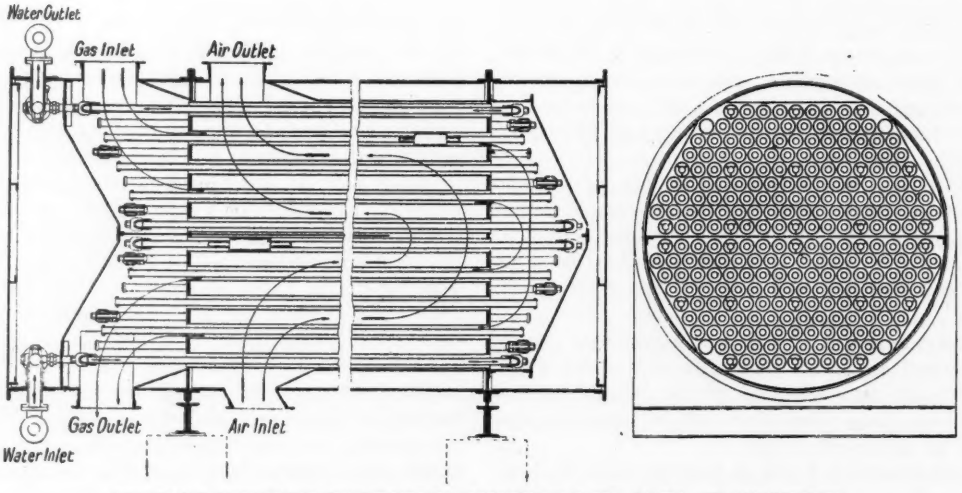
BY COMBINING an air preheater and an economizer, A. E. Leek of Wigan, England, has developed equipment that makes possible a more exhaustive extraction of heat from the flue gases, thereby increasing the efficiency of the boiler plant to about 80 per cent. This apparatus is called the Supermiser.

An essential feature of the Supermiser is the use of pairs of concentric tubes. The flue gases pass through the annular space between the inner and outer tubes; whereas the feedwater to be heated passes in one direction through the inner tubes and the air to be heated in the opposite direction over the outside surface of the outer or flue gas tubes. The tubes are supported between two tube plates in a horizontal steel shell. The outer or flue gas tubes are expanded into the tube plate at one end and merely close-fitted in the holes in the tube plate at the other end to provide for expansion and contraction of the tubes. The feedwater tubes are supported inside the flue gas tubes by means of thin radial fins parallel to the tubes and so designed as to offer the minimum resistance to the flow of the gases.

In the larger Supermisers, the water is divided into two or more circuits. The water tubes are connected in series by headers having removable caps. They are easily removed and accessible through the doors in the end boxes of the Supermiser. A horizontal division plate is provided about the center of the Supermiser and reaches nearly to the front end where the gas and air connections are located. Thus the incoming air is forced to move nearly the entire length of the tubes of the one-half section before it enters the other half section. A high-speed flue gas fan is placed near the outlet to create a suction which draws the flue gas through the Supermiser at a velocity of 75 ft. per sec. at the inlet end of the tubes. Removable curved baffles are used in the end boxes. Another high-speed fan forces outdoor air through the Supermiser and delivers it, after being heated, at a slight pressure, through an insulated sheet metal duct to the boiler furnaces, pressure being regulated by dampers at the boiler front.

In a test conducted by the National Boiler and General Insurance Co., Ltd., of Manchester, England, on a Supermiser installed on a Lancashire boiler, water was evaporated in the boiler plant at the rate of 8361 lb. per hr. The temperature of the flue gas was 786 deg. F. at the inlet and 246 deg. F. at the outlet. The temperature of the air was 61 deg. F. at the inlet and 363 deg. F. at the outlet. The water had a temperature of 115 deg. F. when entering the Supermiser and of 284 deg. F. when leaving.

Gross overall thermal efficiency was found to be 85.04 per cent. The heat absorbed for operating the draft fans amounted to 1.94 per cent, so that the net overall thermal efficiency was 83.10 per cent. The manufacturers figure that about 2 per cent of the efficiency gained in installing this equipment is required for the operation of the fans; but this is only a fraction of the total increases, the overall thermal efficiency of a boiler plant being raised from 60 or 70 per cent to at least 80 per cent.



SECTIONS THROUGH SUPERMISER WHICH IS 3 FT. 10 IN. IN DIAMETER

Pure Air Increases Power *of* Combustion Engines

New Method of Scavenging Two-Cycle Internal Combustion Engines Raises M.E.P. and Makes Possible Greater Piston Speed Range

SCAVENGING HAS LONG been the major problem of the two-cycle internal combustion engine. Because of inadequate removal of burnt gases, engines of the two-cycle type fall far short of furnishing power double that of the four-cycle type for the same cylinder dimensions and speed, as would otherwise be expected of them.

Insufficient time of opening of the ports has been assumed to be the principal difficulty encountered in the proper removal of the burnt gases and admission of the new charge but the real cause has probably been the improper method employed to admit the scavenging air and combustible charge so that impinging streams and swirling currents cause the scavenging air to mix with the burnt gases rather than push them out of the cylinder in a smooth sweeping flow. Although scavenging streams have been intended to fill and empty cylinders, they have heretofore never been cylindrical in form.

No such problem exists in the four-cycle engine for, as the piston advances during the exhaust stroke, it pushes a cylindrical stream of gas out ahead of it and, as the piston returns on the suction stroke, it draws behind it a cylindrical stream of new charge.

In the case of crank case compression engines, a further difficulty is presented due to the limitation of the air injection pressure which reduces the amount of air that may be injected in a given time. In larger sized engines, separate air pumps have been provided to force the air into the cylinder at a higher pressure and as much as 50 per cent of excess air is used in order to effect better scavenging, even at a sacrifice of the power required to compress this air and at an increased cost for equipment.

Retained Burnt Gas Reduces Engine Capacity

Various attempts have been made to solve the problem of scavenging by increasing the speed and varying the time of opening and closing the ports. Also various methods of directing the flow of the incoming excess scavenging air or charge have been tried in order to sweep the cylinder clean of burnt products but two-cycle scavenging is still inefficient as will be seen by the comparatively low mean effective pressure and the speed latitude is still small.

Burnt products retained in the cylinder reduce the capacity in various ways. They displace pure air and combustible that could otherwise come into the cylinder; they prevent proper cooling of cylinder walls during the scavenging event; they give up heat to the incoming charge, hence expand it, thus reducing the amount of charge and they vitiate the combustible mixture, thus weakening the explosive force and reducing the power generated. Furthermore, if a large quantity of burnt gases is left in the cylinder, it is likely to surround the spark plug and delay the new charge in igniting.

Based upon the remarkable success of the use of a "horseshoe flame" in increasing the efficiency of heat transfer in various sizes of industrial furnaces of the Chapman-Stein Furnace Co., William B. Chapman has developed a new method of scavenging, which consists in causing the incoming charge to flow along the cylinder wall in a thin annular film at high velocity to the opposite end of the cylinder and then double back behind the spent charge through the entire length of the cylinder, pushing the burnt gases out ahead of it. It was believed by Mr. Chapman that, if horseshoe flames varying in length from 1 to 24 ft. could be used in industrial furnaces to obtain more uniform scavenging, consequently higher efficiency, the principle involved could be adapted successfully to scavenging a two-cycle engine and results of tests on an engine with which he provided this new form of scavenging appear to have borne out his prediction.

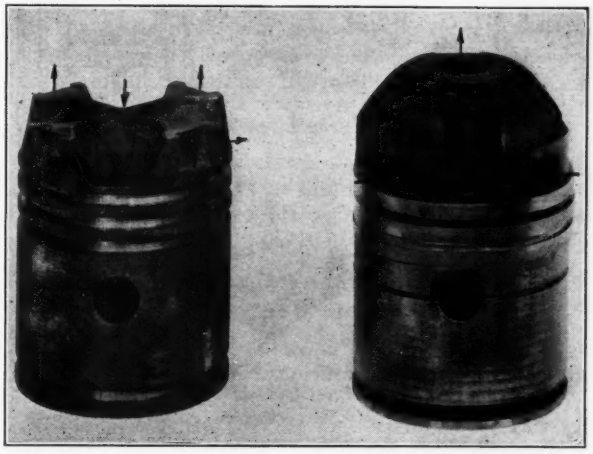


FIG. 1. DEPRESSIONS IN PISTON HEAD DIRECT STREAMS OF INCOMING AND OUTGOING GASES

FIG. 2. FORMER TYPE OF PISTON HEAD WHICH WAS DISCARDED BECAUSE IT HEATED AND RESTRICTED INCOMING CHARGE

Depressions in Piston Head Direct Gas Streams

Inlet and outlet ports of the engine, which are arranged alternately in a ring around the cylinder, are opened and closed by the piston in the usual two-cycle manner. The path of flow of the incoming charge and outgoing gases is directed and determined by the contour of the piston head. Depressions or channels in the piston head direct the incoming charge lengthwise of the cylinder in a thin annular stream of high velocity

along the wall and another set of depressions gather the waste gases and guide them outward as shown in Fig. 1.

In order to determine the comparative value of this new scavenging feature, a two-cycle, single-cylinder, 3½ by 3½ in. gasoline engine of the conventional 3-port type with crankcase compression was purchased second-hand. Before making any change on the engine, it was

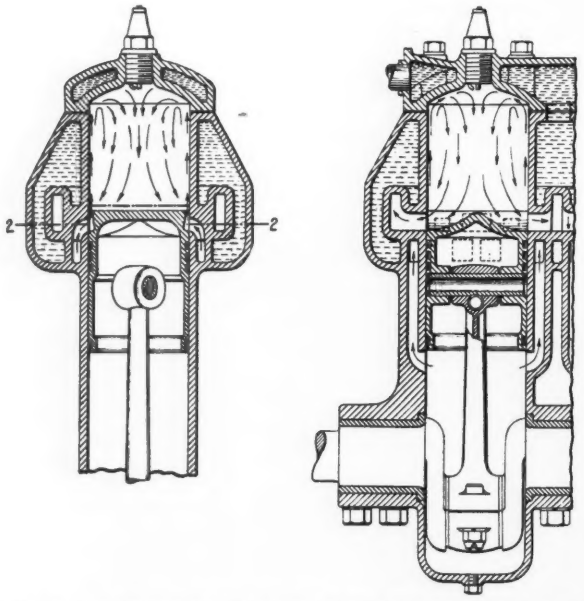


FIG. 3. DRAWING SHOWING HOW STREAMS OF GAS PASS INTO AND OUT OF THE CYLINDER

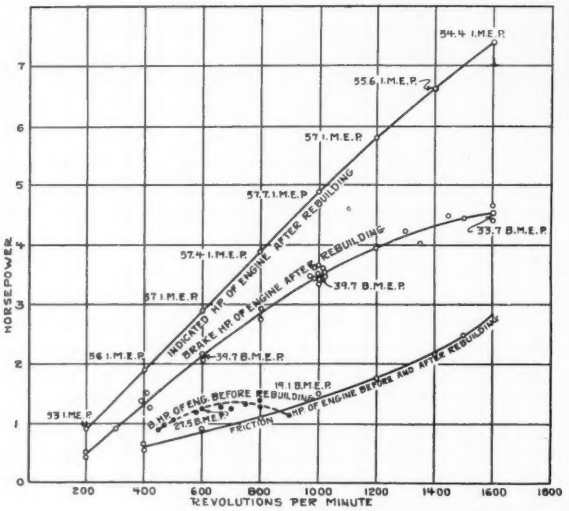


FIG. 5. COMPARATIVE RESULTS OF TESTS MADE ON SMALL SECOND-HAND ENGINE WHICH SHOWS REMARKABLE IMPROVEMENT OBTAINED BY USE OF CHAPMAN SCAVENGING

tested and found to develop 28 lb. brake mean effective pressure and the speed range was found to be limited to from 450 to 900 r.p.m. This piston was then removed and replaced by one arranged to produce a horseshoe-shaped path for the incoming charge, as shown in Fig. 2. The engine then developed 32 lb. brake mean effective pressure and could be operated under full load or at no load at speeds varying from 200 to 1200 r.p.m. It was thought, however, that the passages through the piston head not only heated the incoming air too much but also offered resistance to the incoming charge.

Increase in Speed Results

The form of piston Fig. 1, which overcame these objections was then made and substituted for the form Fig. 2, and arranged in the cylinder as shown in Fig. 3. After this change, the brake mean effective pressure was 38.8 lb. and the speed could be increased to 1800 r.p.m. The engine could be run with or without load and no tendency to backfire or pre-ignite developed but as the engine had only a single-acting, single cylinder and no provision was made for balancing, it could not be run with safety at a higher speed. The compression ratio was 5.9 to 1. These tests were made by Professor Daniel Roesch of the Armour Institute of Technology.

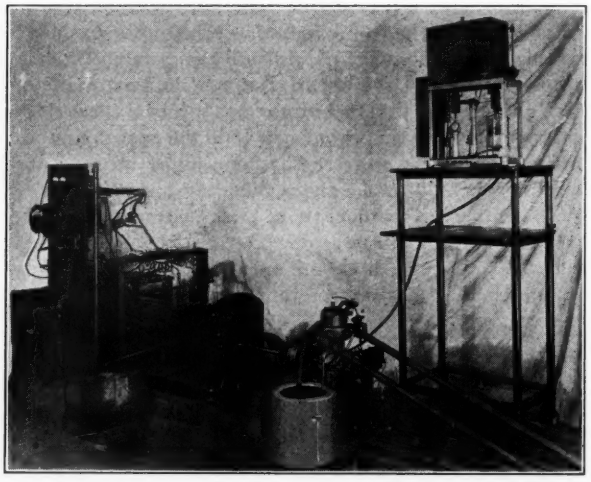


FIG. 4. ENGINE AS SET UP FOR TEST SHOWING CARE TAKEN TO OBTAIN RELIABLE RESULTS

Later, an improved carburetor was installed and additional tests, in which an electric dynamometer was used, were made by the Healey Aeromarine Bus Co. of Keyport, N. J. In these tests the engine averaged 3.5 br.hp. at 1000 r.p.m. and 4.5 br.hp. at 1600 r.p.m. and a brake mean effective pressure of 40 lb. was developed. The engine was found to be rather badly worn although the compression was good. If it had been in better condition, it is believed that still higher values would have resulted for the friction load was high as will be seen in Fig. 5. The above increase of from 28 to 38.8 lb. m.e.p. before installation of the new type of carburetor represents a gain of 38.6 per cent. Tests were also made on the engine, after a 20-in. dia. propeller had been attached to its shaft, during which the propeller was immersed in a tank of water. It is estimated that the added expense of equipping an engine of this size for this type of scavenging will be from $1.00 to $2.00 per cylinder.

Comparative results of tests made on the small second-hand, two-cycle engine with and without Chapman scavenging are shown in Fig. 5. Decided improve-

ment is seen. It will be noted that the indicated mean effective pressure remains almost constant for all speeds. The upward turning of the friction load curve at the high speeds is probably due to the greater amount of work required to overcome the excessive vibration at these speeds.

Conclusions

Conclusions that may be drawn from the work already done are as follows:

1. Distinct improvement in scavenging two-cycle internal combustion engines has been made in a simple and inexpensive way.

2. Large increase in capacity has been made for crank-case compression engines, with marked improvement in efficiency.

3. A much greater range of speed for crankcase compression engines has been attained without affecting the indicated mean effective pressure.

Balancing Heat and Power in Industrial Plants

There Are Opportunities for Economies in Increased Boiler Pressures, Higher Superheats, and by Reducing the Back Pressures to the Lowest Possible Point. By R. V. Kleinschmidt[1]

INDUSTRIAL PLANTS use large amounts of heat in such processes as drying and evaporating, water heating, cooking and digesting, and in kilns, furnaces, and ovens. Moreover, all industrial plants have power and electric-lighting loads. When all of the power used in the plant is generated without rejection of heat in condenser water, the power and heat loads may be said to be balanced.

TABLE I. HEAT-POWER SURVEY OF BOOK-PAPER MILL

Unit	Live steam, lb.	Power developed, kw.	Exhaust, lb.	Exhaust steam used, lb.	Pressure, lb. per sq. in.	
Beater engine	20,000	520	17,700	....	175	
Variable-speed engines	4,400	100	4,000	....	175	
Boiler-room auxiliaries	1,000	10	900	5,000	175 and 10	
Paper-machine driers	8,000	...	....	4,000	40	
Coating-mill driers	400	...	....	13,600	10	
Evaporator	5,000	...	....	....	40	
Sulphite digesters	5,000	...	....	....	80	
Soda digesters	2,000	...	....	....	110	
Bleaching	4,200	...	....	....	10	
Chemical plant	2,000	...	....	....	40	
Total summer steam	52,000		22,600	22,600		
Winter space heating	10,000					
Total winter steam	62,000					
Total engine power		630				
Water power, owned rights		350				
Water power, purchased water		750				
Conversion losses		120				
Total load if all electric		1850				
Distribution of Process-Steam Requirements						
Pressure, lb. per sq. in.		10	40	80	110	
Exhaust steam, lb.		18,600	4,000	....	....	
Live steam reduced, lb.		4,600	15,000	5000	2000	
Total, lb.		23,200	19,000	5000	2000	Totals
Available kw-hr. from 175 lb. per sq. in. sat.		740	355	54	11	1160
(Based on 60% eff.) from 300 lb. per sq. in. sat.		865	523	92	28	1508

Important factors that determine or affect this heat-power balance are:

1. Boiler steam pressure and superheat.
2. The pressures and temperatures required by the process.
3. Type and characteristics of power-generating equipment.
4. Utilization of waste heat.

In familiar terms, the maximum theoretical power that can be developed by an engine per pound of steam handled depends fundamentally on the temperature of the steam entering and leaving the engine, and therefore on pressures and superheats. The portion of this maximum theoretical power which the engine will actually deliver depends on how closely it follows the theoretical cycle and on mechanical losses.

[1]Research Engineer, Arthur D. Little, Inc., Cambridge, Mass. Abstract of a paper presented before the A. S. M. E.

Since the combustion of coal liberates heat at a temperature far above that required in most industrial processes, this heat can generate power before being used in process. The power so generated will be referred to in this discussion as "by-product power."

The Heat-Power Survey

In attempting to balance the heat and power loads of an industrial plant, the first step should be a careful survey, involving accurate measurements, of the heat and power required by the various processes. In making this survey, careful attention should be paid to points where slight changes in operating procedure may make substantial improvement in the balance of heat and power. For this work, intimate knowledge of the process concerned and coöperation with the plant superintendent are necessary. Table I summarizes the results of a heat-power survey of a large mill making coated book paper. This plant is of particular interest on account of the great variety of its heat and power requirements.

TABLE II. TYPICAL HEAT-POWER RATIOS

Plant	Exhaust temperature, deg. fahr.	Heat-power ratio B.t.u. per kw-hr.
Non-condensing plant	212	30,000 up
High-pressure central station, condensing	80	15,000
Mercury-steam plant	80	10,000
Diesel-engine plant	700	10,000
Diesel-steam plant	80	8,000

Heat-Power Ratio

In order to determine at the outset whether a balance of heat and power can probably be worked out and along what lines, it is desirable to determine the overall heat-power ratio for the plant. This ratio is the total process-heat requirement divided by the total power requirements, and is expressed in B.t.u. per kw-hr. By comparing this ratio for a given plant with the values given in Table II, the probability of a balance of heat and power will be readily determined.

Accurate determination of the necessary steam and power conditions to produce a proper balance can be greatly simplified by certain charts that have been used with success for this purpose by the author. The object of these charts is to show at a glance what steam conditions are necessary in order to get a given amount of power from a definite quantity of process steam. Figure 1 shows one such chart which is exceedingly useful in considering the effect of decreasing exhaust pressure or

increasing boiler pressure. This chart is based on an ideal engine, but it is a simple matter to allow for any actual efficiency with regard to the ideal Rankine engine.

Although decreased back pressures is usually the simplest method of increasing the power from process steam, it is frequently necessary to use high boiler pressure as well. It is possible to deduce from Fig. 1, the fact that the percentage increase of available power due to raising the boiler pressure a given amount is greater for high exhaust pressures than for condensing plants.

For example, raising the boiler pressure from 200 to 400 lb. with 42 lb. back pressure will increase the theoretical power per thousand pounds of steam from

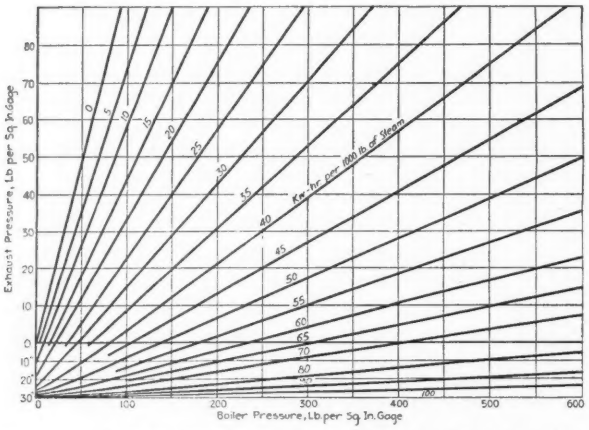


FIG. 1. POWER DEVELOPED BY IDEAL ENGINE FOR VARIOUS STEAM CONDITIONS

30 to 45 kw-hr., an increase of 50 per cent, while at 26-in. vacuum the same increases in boiler pressure will raise the available energy from 90 to 102 kw-hr., or an increase of only 13 per cent. The industrial plant that is using exhaust steam under pressure may well consider the advantages of boiler pressures as high as are used in the best condensing central-station plants.

For problems involving superheat, which includes practically all power-plant problems today, it is necessary to use some such chart as Fig. 2. This chart shows the theoretical power obtainable in going along the theoretical expansion line from any pressure and superheat indicated in the lower right-hand quadrant to any final pressure. The saturated-steam condition is taken as the horizontal axis, and the total power developed by 1000 lb. of steam is the sum of the powers indicated in the superheated and wet-steam regions.

Although the effect of superheat in increasing the power developed from a given amount of steam is not large, the addition of superheaters is usually not a difficult problem in an existing boiler plant, and it frequently happens that the resulting economies are very substantial. Quite aside from any question of heat and power balances, superheat is always essential in high-pressure boiler installations in order to insure dry steam to as many as possible of the turbine stages. It is probable that the advantages of superheat even in low-pressure boiler plants have received far too little attention in the past.

Theoretical curves given in Figs. 1 and 2 must, of course, be modified in any actual case by the efficiencies and characteristics of the equipment in which the steam is to be used. The two main types of steam power-generating equipment—turbines and engines—have very different characteristics. The efficiencies of turbines do not vary greatly over various pressure ranges. There is some decrease in stage efficiency at very low pressures. But factors of equal or greater importance are the size of unit and the degree of efficiency that is justified in view of increased costs of high-efficiency designs.

Turbines below 1000 kw. decrease rapidly in efficiency with decreasing size. Such small turbines range from 40 to 65 per cent in efficiency. The sizes above 1000 kw. range from 50 to 85 per cent in special cases. Special high-efficiency turbines are expensive, but are frequently justified in such plants as paper mills, where the loads are steady and continuous. Such mills occasionally operate with overall annual load factors of over 75 per cent, and under such conditions specially designed turbines are in order.

Attention should be called to the fact that special high-efficiency turbines are normally designed for very

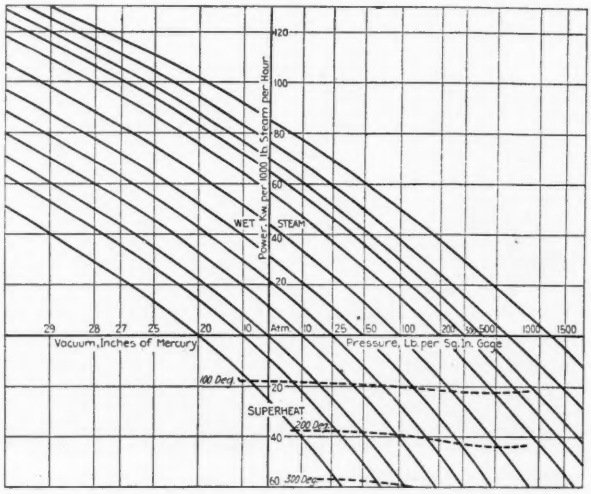


FIG. 2. POWER DEVELOPED FROM SUPERHEATED STEAM BY IDEAL ENGINE

closely limited conditions as to pressures, steam flows, and power loads. If plant conditions are subject to considerable fluctuation, overall efficiencies may not be improved by such design.

Efficiencies of reciprocating engines vary much more than do those of turbines. The efficiencies in small sizes are noticeably higher than for small turbines when the engines are in good condition. Engines do not utilize low or very high pressures as well as turbines. The steam consumption of a reciprocating engine is not affected nearly so much by changes in back pressure as is that of a turbine. If a small amount of steam at high back pressure is needed, it can frequently be obtained from engines having throttling governors without a measurable increase in their steam consumption.

Maximum-efficiency point of an engine usually occurs between ½ and ⅞ load, while for a turbine it is generally at or near full load.

We have so far considered only steam because it is by far the most frequently used medium for distributing and utilizing heat. There are several sources of heat for

power generation which are usually referred to under the general heading of "waste heat." Even small amounts of waste heat can frequently be utilized by the use of a mixed-pressure turbine.

In connection with the utilization of waste heat, the use of air heaters as developed for power plant work is of special interest. It is frequently suggested that where air is used in large quantities for drying, the most suitable source of heat is an air heater in the boiler flue. A more careful analysis shows, however, that from the point of view of obtaining maximum power from a given consumption of coal, it is more desirable to use this heated air as far as permissible in the boiler furnaces, thereby increasing the liberation of high-temperature heat and the output of high-pressure steam. This steam can then develop by-product power, and the low-temperature exhaust can be used for air heating. There is a definite theoretical advantage as well as the added convenience of steam piping, as compared with air ducts, for transferring large quantities of heat.

Internal-Combustion Engines

A development which gives promise of materially widening the field of balanced heat and power loads in industrial plants is in connection with high-efficiency internal-combustion engines. There are a number of factors in the economic utilization of such engines which have not been worked out with complete satisfaction, but hot water from the cylinder jackets of these engines, heated further, if desired, by the exhaust gases, can be used in many industrial operations. There is a possibility for the commercial development of a heat and power unit based on a Diesel-type engine which will combine an efficient and compact small-size generating unit with a boiler heated by exhaust gases to furnish small amounts of process steam.

Stop Losses in Services Rendered to the Plant

Part I. Investigation of the Uses of Water, Steam and Mechanical Power Throughout the Factory Frequently Points to Possible Economies

SOMEWHAT the same feeling comes over an engineer who has used all his energies to put the services of his plant out at the least possible cost and then sees these services wasted in the factory, as comes to a parent whose hard-earned savings are squandered by a profligate son. Out of sheer self-defense of his department, the power plant engineer is sometimes forced to step out into the factory and supervise the use of the services he makes available to the other departments of his company.

Quite commonly, the load on a power plant will be observed to grow, the increase usually being accompanied by an increasing output of the factory and additions and changes in processes. The increase in load may easily be thought to be due entirely to the increased output of the factory but some day the power plant is likely to reach its maximum capacity and considerable expenditure for new equipment may be contemplated. This is the time when a plant survey is in order to ascertain how services can be used more efficiently.

Each factory, of course, has its peculiarities but a few general principles can be laid down as a guide in checking losses. No matter what the nature of the investigation may be, thorough results can be had only by isolating each element entering into the problem and giving each detail careful consideration. One fortunate thing about engineering problems is that, in nearly every case, advantages and disadvantages of present or proposed arrangements can be calculated mathematically, thus eliminating guesswork.

In line with this program, the services of an industrial power plant can usually be separated, for survey purposes, into the furnishing of water, steam, mechanical power, electricity, compressed air and refrigeration. As a matter of economy, these services should be used only when they serve a useful purpose and nothing should be allowed to escape which has value either as material or as a source of heat or power.

Quite generally, industrial power plants furnish water under pressure for general purposes and workmen sometimes get the idea that water is cheap because "we pump it ourselves." They may wish cool water and will allow it to run until they think it is as cool as it will get, or, desiring hot water, they allow the water that has cooled in the service pipe to run to waste.

Checking Losses in the Water System

Waste of cold water, as above, seems needless, but sometimes the cold water piping runs along with the hot water piping or in the proximity of steam piping and there is not only a waste of water but also a waste of heat caused by this arrangement. If such a condition exists, steps should be taken to isolate the piping, instruct the workmen in the use of water and install spring faucets wherever feasible.

All hot water service piping should be arranged so that the water in the main piping will be in constant circulation, the service piping to faucets being as short as possible.

In many plants, the water used for service and industrial purposes must be softened and any that runs to waste is doubly expensive.

If the plant is serving a high building, it may not be necessary to pump all the water against a pressure necessary to serve the top floors and considerable power may be saved by dividing the water system into two or perhaps three systems run at different pressures.

For example, if water is being furnished at 50 lb. pressure whereas for three-fourths of the water used 25 lb. pressure is sufficient, it is quite apparent that, in round numbers, 37.5 per cent of the power for pumping can be saved by rearranging the water supply system.

Many industrial processes require hot water and also water for cooling purposes. A study of the quantities and temperatures will in many cases reveal that either the warm cooling water can be used for hot water purposes or if it is contaminated the heat may be saved

by the use of a heat exchanger. Such methods of saving water and heat are common in ice plants, canneries and packing houses. The principle involved here is that wherever heat is required it should be extracted, as far as possible, from water, vapor or gases that are going to waste and that use should be made of all uncontaminated condensate and treated water, allowing only cool raw or impure water to go to waste after it has served every possible useful purpose in the plant.

Considerable waste of heat in an industrial plant may be due to maintaining the process water at a higher temperature than necessary for its purpose, thus increasing the radiation from piping and containers and also the loss due to vaporization when drawn out of the piping for use. In any process carried on under atmospheric pressure, any water temperature above 210 deg. F. is, for all practical purposes, a waste of heat. For this reason, exhaust steam from engines, pumps and turbines at not more than 5 lb. gage back pressure will give sufficient temperature to water for any hot water process, provided of course, sufficient exhaust steam is available for the purpose.

THICKNESSES OF INSULATION USED ON STEAM PIPING

Steam Pressures (Lb. Gage)	Steam Temperatures (Deg. Fahr.)	Thickness of Insulation		
		Pipe larger than 4 in.	Pipes 2 in. to 4 in.	Pipes ½ in. to 1½ in.
0 to 25	212 to 267	1 in.	1 in.	1 in.
25 to 100	267 to 338	1½ in.	1 in.	1 in.
100 to 200	338 to 388	2 in.	1½ in.	1 in.
Higher Pressure or Superheat	388 to 500	2½ in.	2 in.	1½ in.
Higher Pressure or Superheat	500 to 600	3 in.	2½ in.	2 in.

Steam Should Be Made to Give Up All Its Heat

In industry, steam has three purposes for which it may be used—power, heat and distilled water. Any condition which will reduce the effectiveness with which the steam will do its proposed work is a loss which should be investigated.

Whenever steam is transmitted, there is always loss due to heat radiation and friction. Radiation is directly proportional to the difference in temperature between the steam in the pipe and the surrounding atmosphere, therefore, higher temperature than is actually required will cause an unnecessary loss of heat. Pipe insulations now on the market are so effective, however, that if sufficient insulating material is used this loss can be reduced to a small amount. The accompanying table from the Transactions of the American Society of Heating and Ventilating Engineers gives the thicknesses of covering ordinarily used on piping.

Insulation, however, is not indestructible and although the surface may not be broken, vibrating steam pipes have been known to shake the insulating material to a loose form which falls to the under side of the pipe leaving nothing but the binding canvas to cover the upper side of the pipe. Such a condition could easily exist without being observed and the heat loss may go on for some time if a check is not made regularly of the amount of condensate collected from steam lines which is a measure of the heat lost by pipe-line radiation.

Friction of steam in piping results in reduced pressure at the end of the line, which also means reduced temperature. For this reason, the steam piping should be as large, short and direct as possible.

Often a growing industrial plant extends its piping in various directions without thought of the entire piping problem. As a result, some of the piping may be overloaded, various departments may complain of low steam pressure, steam may be compelled to take an unnecessarily circuitous course through the plant and the losses due to radiation and friction gradually grow excessive as the plant extensions are made.

To reveal the true situation, an investigation of the steam flow and pressure drop at various points in the piping system is quite essential. In many cases, feeder piping to centers of distribution will relieve a pressure drop situation that has developed in a growing industry.

As a rule, the transmission of steam to remote distances for the purpose of driving an engine or pump is a practice to be avoided where electric power is available, as the latter is usually the more economical. If such an arrangement exists, the situation should be studied with the idea of eliminating the long steam piping, the radiation losses of which continue as long as the pipe is under steam pressure even when the engine is shut down by closing the throttle valve.

Getting Double Duty Out of the Steam

Exhaust steam is valuable; it contains heat that cost money to generate. To employ that heat for a useful purpose is an objective to be sought in every plant. One great difficulty is that exhaust steam, as such, cannot be stored. It is possible, however, to store the heat released from exhaust steam in accumulators and hot water tanks if they are properly insulated. This provision, in many plants, saves the use of live steam at times while at others exhaust steam is being wasted to atmosphere. Storing heat is particularly applicable in laundries, hotels, hospitals and packing houses where the demands for power and hot water are not simultaneous.

Load conditions in some plants are such that large quantities of steam are required intermittently and condensate comes back to the heater at a time when the demand for feedwater has lessened, with the result that the condensate overflows the heater and runs to the sewer while during the peak load on the boiler cold feedwater flows to the heater through the regulating valve.

To avoid this loss of water and heat, a hot water storage tank is sometimes used, being of sufficient capacity to carry the boiler over the peak and located, when possible, in a position from which the condensate will flow by gravity through a float controlled valve to the heater. The condition may, however, sometimes be averted by arranging the program of the factory so as to distribute the use of the steam more evenly throughout the day.

In making a survey of the steam losses, every point where steam escapes to atmosphere should be investigated. All leaks, of course, should be stopped but there are exhaust heads, relief valve discharge pipes, safety valves, trap discharges and heater vents that are provided to permit steam to escape under certain conditions. Often, however, more steam is escaping than is necessary and again, changes can sometimes be made in the heat balance of the plant which will permit saving considerable of this steam.

Through every factory, considerable mechanical power transmission equipment is employed, consisting of shafting, belting, chains and gears. When this equipment is in good working condition, the losses are not great but they run up surprisingly with seemingly minor disorders.

Investigating Mechanical Power Losses

Shafting that is out of alinement is not only the source of a loss of power but often causes the breaking of a shaft, running off of belts and continuous bearing troubles. Regular inspection of all line shafts should be made at least four times a year and more frequently if bearing troubles prevail. In a growing plant, it is not uncommon to find a line shaft overloaded. New machines are installed and as long as there is room on the shafting, pulleys are added without consideration of the size of the shaft or the spacing of the bearings. Such a condition is sure to bring power transmission troubles.

With modern instruments it is an easy matter to check up the alinement of a shaft and with adjustable bearings, any misalinement can be corrected without great difficulty.

For the purpose of a power loss survey, the losses due to belting that should be investigated are slipping, tension and any incorrect operating conditions such as rubbing some stationary object, running in dust, vapor or dripping water, imperfect joints, oil on belting and pulleys out of alinement.

Probably the most common power loss in the operation of belts is slipping. The causes are numerous but they can usually be traced down to the condition of the belting material. Tension, of course, plays an important part, the tendency on the part of workmen, who are not familiar with belting, being to tighten belts to a fiddle-string tension when they are observed to slip thus increasing the power lost in bearing friction, shaft deflection and strain on the belt. A properly designed belt drive should run slack and whenever an engineer sees a tight belt it is time to investigate the condition of the belt and check up on the service to see that the design is correct, the belt is pliable and its surface clean.

Wherever a belt has a tendency to run off its pulleys, some condition is wrong. Probably the most frequent cause is overloading but incorrect alinement of pulleys, improper crowning of pulleys and defective joints are common causes. To prevent the annoyance of belts running off, workmen frequently nail up a block against which the edge of the belt rubs. This not only causes a loss of power but injures the belt and wherever any such device is required to hold the belt on the pulleys the design of the drive and belt condition should be checked.

In late years, chain drives have grown in popularity but they, too, must be given attention to maintain them in best working order. Lubrication is necessary and proper tension is extremely important as the limits are not so wide as with belting. Chains can be overloaded with resultant breaking of pins and jumping of cogs. Alinement of wheels is a necessity to prevent breaking the chain and loss of power. Any disorders in the operation of a drive such as breaking of pins, jumping of cogs and heating of bearings should invite an investigation as to the design of the drive for the service it is performing.

Gear drives are used in industrial plants principally on machines where definite speed ratios are required. Any unusual loss of power here will usually be evidenced by heat, rapid wearing of gears, excessive noise or slipping of teeth. Each gear showing any of the symptoms mentioned should be given individual consideration not only to reduce power loss but to avoid a forced shutdown of a machine.

(To be continued.)

The Care of Switch Oil

By W. E. Warner

ON HIGH POWER high voltage circuit breakers and switches, it is usual for the switch to be oil immersed, the actual break taking place under oil. The oil quickly extinguishes the arc but its heat causes the formation of free carbon and hydrogen, the carbon falling to the bottom of the tank while the hydrogen rises to the top, where if the tank is ventilated it escapes to the atmosphere but if the tank is sealed it collects under pressure. This gas must not come in contact with air or a high explosive mixture will be formed.

To meet these conditions satisfactorily, a very highly refined mineral oil is needed, having a high dielectric strength, a high specific resistance and a low sludging value. A good transformer oil will meet these requirements, and if highly refined will permit a minimum of carbon formation. These switches and their oil should be inspected periodically. If in continuous use, the inspection should be made every three months but if the atmosphere is dust laden or impure, the interval should be shortened to six or eight weeks.

Judging Condition of the Oil

The condition of the oil can be judged by taking a sample from the bottom of the tank and placing it in a test tube. If this is held up to the light, any sediment or carbon will be plainly visible, while if it heated to just above 212 deg. F. spitting and spluttering of the oil will indicate moisture.

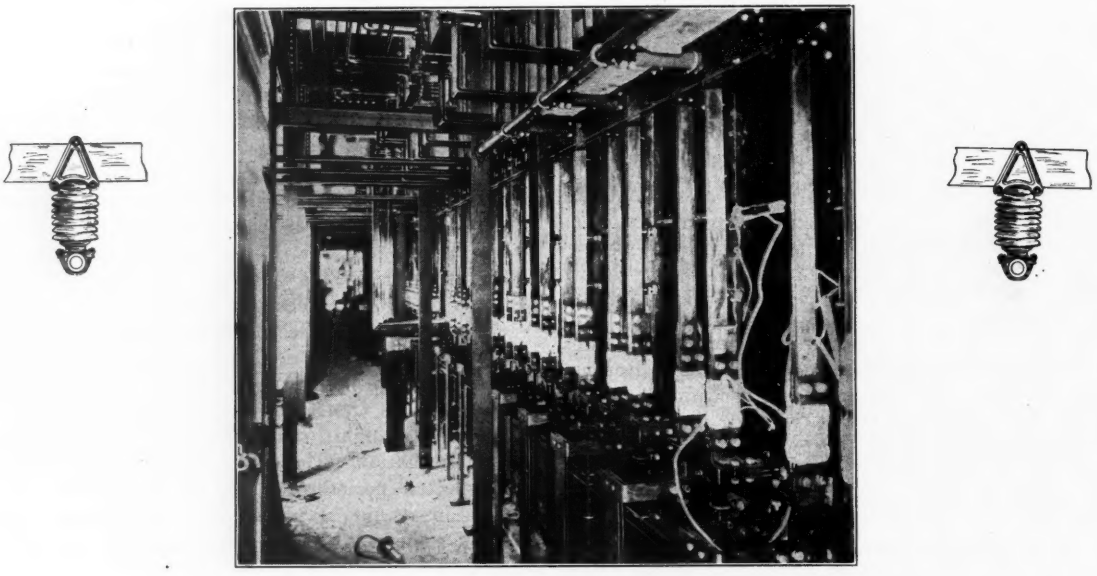
If either impurities or moisture are present, the whole of the oil should be passed through either a centrifugal or pad filter as this will remove both. When the life of the oil as stated by the makers has passed, it should be discarded and new oil used; testing with proper equipment at regular intervals is advisable, since this will show any deterioration of the oil. The oil tank should be kept filled to the correct level and neither overfilled or underfilled, one being as harmful as the other.

Any oil will quickly absorb moisture from the atmosphere and as oil cannot be kept out of contact with the atmosphere at all times, moisture is always liable to be present in an oil, which will quickly lower its dielectric properties. A low grade oil will always develop excessive sludge, making it advisable to use a more highly refined oil. This, although more expensive, will be cheaper in the long run.

New tariff schedules for power users, supplied by the Illinois Light & Power Corp. in central Illinois, effective April 1, fixed a charge of 6 cents a kilowatt-hour for the first 400 kw-hr.; 3½ cents for the next 600 kw-hr.; 2¾ cents for the next 1000 kw-hr. and 2 cents for all in excess of 2000 kw-hr.

Features of A. C. *and* D. C. Bus Bar Design

*By T. H. McCauley**



IN THE EARLY DAYS of switchgear engineering, buses and connection bars were designed upon a basis of given amperage per square inch of cross-sectional area, usually 800 or 1000 amp. per sq. in. Consideration will show and experience proves, that this is not a logical basis, owing to the varying conditions, such as variation in radiation, proximity of other current carrying parts, skin effect and reactance depending on the arrangement of buses and the form and dimensions of buses and connections. Therefore, the standard and modern practice is that the ampere ratings of the buses and connection bars shall be based upon their temperature rather than current density.

Connection bars and buses are usually made of copper and as copper is an excellent conductor of heat, the same rating standards which are applicable to switching apparatus should be applied to the connections and buses, as otherwise any higher temperatures of these parts would be communicated to the switching devices with possibly injurious results. Accordingly, the standard ratings of connection bars and buses should be based upon a maximum operating temperature of 70 deg. C. This, with an ambient temperature of 40 deg. C., limits the permissible rise to 30 deg. C. (above 70 deg. C. the oxidation of copper commences to take place at a comparatively high rate).

As exceptions to the general rule, a temperature rise of 40 deg. C., that is, a maximum temperature of 80 deg. C., is permissible only in special cases where heat from the bus will not be conducted to the switching apparatus by way of the connections. This applies chiefly to extended bus systems where considerable distances exist between connections of various circuits to the buses and where there are long connections from the switching apparatus to the buses.

Exceptions Due to Different Ambient Temperatures

Another exception to the rule occurs when there is a definite assurance that the ambient temperature is less than 40 deg. C. In such a case, the cross-section of the copper used for connections and buses may be decreased proportionately (the carrying capacity of copper varies approximately as the square of the temperature in deg. C.). Conversely, if the ambient temperature is normally higher than 40 deg. C. the cross-section of the copper must be increased accordingly; however, definite information should be obtained from a reliable source before applying either of the preceding exceptions to the general rule.

In order to keep within the prescribed temperature limits, great care must be exercised in the design of the connection bars not only to obtain ample cross-sectional area for carrying the current, but also to make good joints where necessary. Copper bars of rectangular section are usually used for connection bars.

In alternating-current installations, iron parts such as supports, conduits, floor beams, etc., should not be

*Switchboard Engineering Department, General Electric Co.

placed between the conductors of a circuit in such a manner as to form magnetic loops around a single conductor. This applies even to reinforcing material in concrete compartments. The number of joints in connection bars can be minimized by the use of edgewise bends, flatwise bends and twists as illustrated in Fig. 1.

When joints are necessary, they should have good clean contacts and the component parts should be firmly secured by means of bolts. Soldered joints are not usually recommended, but sometimes owing to space limitations, it is necessary to make them. In such cases, the conection bars should be riveted and firmly secured mechanically before being soldered.

Where connection bars are to be joined together, they can be bolted as shown in Fig. 2.

Factors Determining Bus Bar Layout and Mounting

In designing the arrangement of bus bars and determining the proper number, a number of factors must be taken into account. Not only does the current strength enter in but magnetic and radiation effects are important. For high current capacity, the buses are arranged in tiers. Different sizes of buses are required for direct current and alternating current. For alternating current, heavier buses are required for 60 cycles than for 25 cycles. This is because of eddy currents and skin effects.

The definite arrangement of a set of buses must take into consideration, among other details, the relative location of generator and feeder panels in a switchboard, load factor, possibility of "tapering" the bus, and whether or not transposition is required. These features are briefly treated in the following paragraphs.

For direct-current buses, all groups of laminations should be connected together at every generator. The studs of switches and circuit breakers should not be used for these interconnections because the capacity of the bus may be such that the exchange current flowing through the stud might be beyond its capacity.

A.C. Bus Design

Alternating-current buses present more complicated problems. Not only do such buses require to be laminated as in direct-current buses but on account of the skin effect, they should be separated into groups as in Fig. 5. For certain current capacities, four groups are required, sub-divided into two horizontally separated groups (lower A-1 and A-2, and upper A-2 and A-4). When buses are so divided, that is, in four groups, two tiers of laminations on each are considered as electrically separate units and connections should always run to both groups of such units. Under some conditions, it is found advisable to parallel all groups of laminations in each phase at one or more joints along the bus. Two typical cases where such paralleling would be desirable are:

1. Where several generators are connected to one end of the bus and feeders are taken from the other end. In this case, some of the generators are connected to A-1 and A-2 others to A-3 and A-4; therefore, in order to obtain uniform loading on the bus under all conditions, particularly when one of the generators is shut down, it is necessary to parallel all groups in each phase at some point between the generators and the feeders, as is illustrated in Fig. 3.

2. When several generators are connected to a bus and feeders are taken off between the generator connections. Here, again, some of the generators are connected to one unit and the remainder to the other unit. Since the feeders are taken off between generator connections, it will be necessary to parallel all groups in each phase at each generator (except where the capacity of the generator is small compared to the other generators) as illustrated diagrammatically in Fig. 5.

For long runs of alternating-current buses, consideration must be given to the fact that there is a difference in the reactance of the individual laminations, which results in unbalancing the current carried, consequently in unequal heating of the bars. It is possible to equalize the current carried by the bars by transposition of the sections on phases 1 and 3, thereby causing a more uniform distribution of current among the bars. This will apply particularly when generator and feeder sections are widely separated or for the arrangement illustrated by Fig. 3. Where bus bar runs are not more than 10 ft., transposition is not necessary. For runs in excess of 10 ft. but less than 20 ft., it is advisable to increase the sectional area of the copper

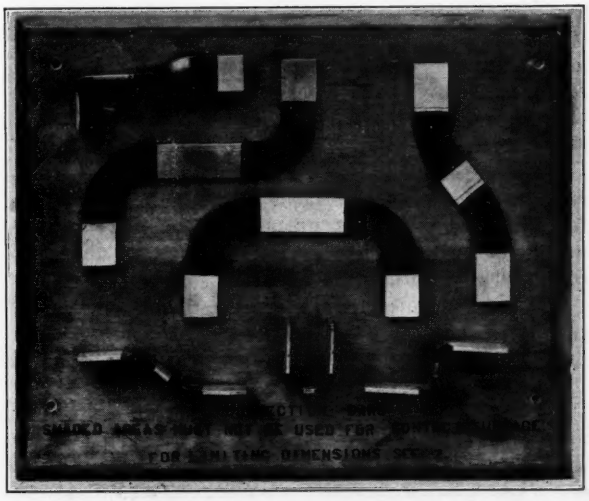
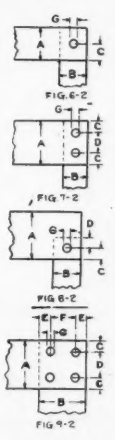


FIG. 1. FORMS OF CONNECTION BARS COMMONLY USED MOUNTED ON DISPLAY BOARD



Bars A	Bars B	Fig.	C	D	E	F	G	Bolts
1	1	6-2	1/2				15/32	3/8
1 1/2	1		3/4				15/32	3/8
1 1/2	1 1/2		3/4				5/8	1/2
2	1	6-2	1				15/32	3/8
2	1 1/2		1				5/8	1/2
2	2		1				5/8	1/2
2 1/4	1		1 1/8				15/32	3/8
2 1/4	1 1/2		1 1/8				5/8	1/2
2 1/4	2		1 1/8				5/8	1/2
2 1/4	2 1/4		1 1/8				5/8	1/2
2 1/2	1	7-2	1/2	1 1/2			15/32	3/8
2 1/2	1 1/2		1/2	1 1/2			15/32	3/8
2 1/2	2		1/2	1 1/2			15/32	3/8
2 1/2	2 1/4		1/2	1 1/2			15/32	3/8
2 1/2	2 1/2	9-2	1/2	1 1/2	1/2	1 1/2	15/32	3/8
3	1	7-2	5/8	1 3/4			15/32	3/8
3	1 1/2		5/8	1 3/4			15/32	3/8
3	2		5/8	1 3/4			5/8	1/2
3	2 1/4		5/8	1 3/4			5/8	1/2
3	2 1/2	9-2	5/8	1 3/4	1/2	1 1/2	15/32	3/8
3	3		5/8	1 3/4	5/8	1 3/4	15/32	3/8
4	1	8-2	1	1/2			15/32	3/8
4 +	1		1	1/2			15/32	3/8
4	1 1/2	7-2	1 1/8	1 3/4			5/8	3/8
4	2		1 1/8	1 3/4			5/8	1/2
4	2 1/4		1 1/8	1 3/4			5/8	1/2
4	2 1/2	9-2	1 1/8	1 3/4	1/2	1 3/4	15/32	3/8
4	3		1 1/8	1 3/4	5/8	1 3/4	15/32	3/8
4	4		1 1/8	1 3/4	3/4	1 3/4	5/8	1/2

FIG. 2. STANDARD BOLTING FOR BUS AND CONNECTION BARS

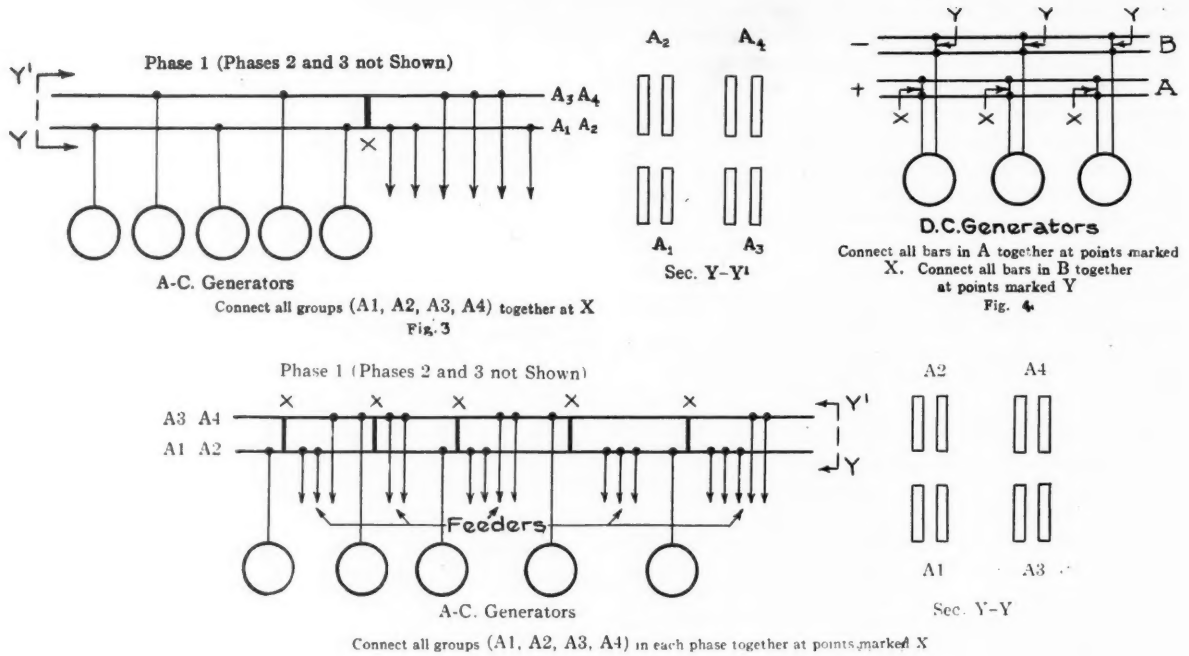


Fig. 3 Fig. 4 Fig. 5

FIGS. 3-5. DIFFERENT BUS ARRANGEMENTS SHOWING POINTS OF INTERCONNECTION

at least 10 per cent rather than to use transposition, which latter probably would be the more expensive. For runs exceeding 20 ft. in length a transposition is recommended.

For appearance as well as convenience and ease of maintenance, there should be adopted a uniformity and consistency in order and arrangement as far as practicable in the insulation of buses and connections. For example, on direct-current switchboards the positive bus and connections may be located nearest the board, at the top and at the right facing the rear of the switchboard. On alternating-current switchboards, phase one may be located in the position corresponding to that of the positive.

Insulation of Bars

In a switchboard room, or where connections are accessible from aisles, no bare connections above 750 v. should be allowed.

NUMBER OF LAYERS OF VARNISHED CAMBRIC INSULATION NECESSARY FOR DIFFERENT VOLTAGES

Volts		Half Lap Windings 0.012 In. Thick V. C.
Above	Up to and Including	
	1,000	3
1,000	2,000	4
2,000	3,000	4
3,000	4,000	5
4,000	5,000	6
5,000	6,200	7
6,200	7,600	8
7,600	8,800	9
8,800	10,000	10
10,000	11,600	11
11,600	13,400	12
13,400	15,400	13

The table shows the number of windings of 0.012 varnished cambric which are required for insulating rectangular bars and rods. In taping a bar, make as many wraps of varnished cambric as are shown to be required in the table, and then apply a layer of good insulating compound to the outside wrapping. Over this wind one-half lap layer of cotton webbing, then cover with two coats of flame resisting paint.

It will be understood, from a consideration of Fig. 7, that a so-called half lap winding is in reality two layers of insulation; for in the half lap winding process, the tape is lapped back 50 per cent as the winding is carried out to the end of the bar.

For fastening connection bars to buses, clamps with bolts are usually used instead of drilling the bars. This provides much greater ease and economy in construction and installation without sacrificing in any way the efficiency of the joint. On direct-current circuits, malleable iron clamps with steel bolts can be used. For alternating-current circuits, it is necessary to use clamps of non-magnetic material (preferably non-magnetic steel) with steel bolts.

It is necessary to support all buses and connections rigidly, not only to give them a better appearance but for the more important purpose of enabling them to withstand any electro-magnetic stresses that abnormal conditions may produce.

The type of bus support for a particular application should be chosen to take care of the ultimate capacity

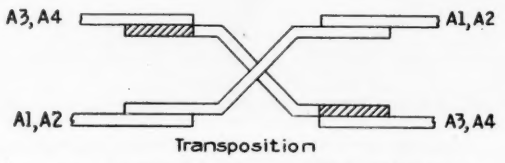


FIG. 6. METHOD OF TRANSPOSING BARS

of the bus; that is, while the present installation may require only the ordinary porcelain post-insulate type of bus support, future extensions may require buses in tiers and a method of support should be chosen accordingly.

There are several different types of bus supports available in order to meet satisfactorily the requirements of various installations.

The insulated rod-type bus support illustrated in Fig. 8 is particularly adapted to heavy bus construction.

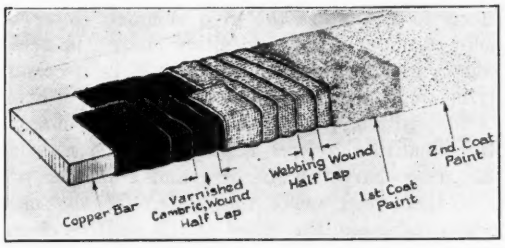


FIG. 7. HALF LAP WINDING

The design provides a means of properly arranging the bars of each individual bus to obtain a maximum efficiency of the conducting copper and to furnish a method of supporting a heavy bus of more than three or four bars in a neat and rigid manner.

By arranging the bus so that each phase or pole is separated into smaller buses, the resulting increased

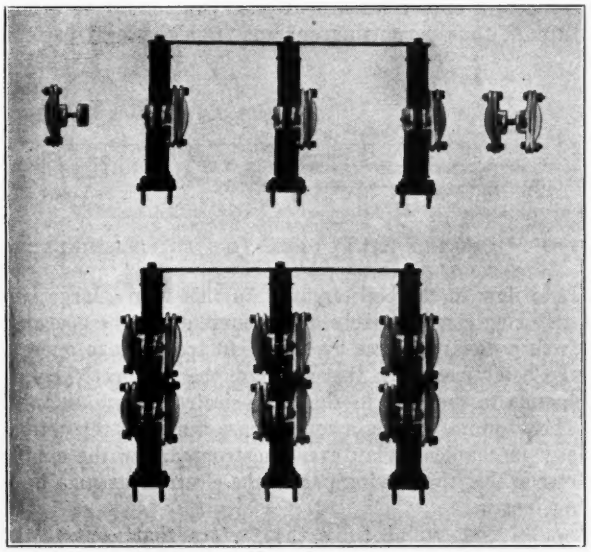


FIG. 8. INSULATED ROD TYPE BUS SUPPORTS FOR 3-PHASE BUSES; SHOWING BUSES ARRANGED IN TIERS, WITH STEEL REINFORCING BAR AT TOP

air circulation permits a higher bus ampere capacity for a given temperature rise. The efficiency is further improved when the separated conductor sections are arranged to approximate a tubular construction of the bus, or in such a manner that the section or tiers could be considered together, as being an incomplete shell of an imaginary tube. It is commonly known that a tube or pipe is the most efficient conductor of alternating current. This is due to the "skin effect" concentrating the current in the outside portion of the cross-sectional area. The tubular approximation obtained by the tier-type support causes a very appreciable improvement in efficiency over that of the conventional bus arrangement. Indications of this may be seen in the bus chart in Fig. 5.

The spacing of the bus support between polarities or phases is determined principally by the necessary clearances recommended between "live" parts for the particular voltage involved. It may not always be sufficient merely to space buses in accordance with recommended dielectrical clearances, since the clamp fitting, and in most cases the caps of bus supports, are in direct contact with the bus, consequently making these parts alive when the bus is energized.

Where buses are located immediately back of the switchboard, supports should be installed at the ends of the bus, and at intervals not exceeding 48 in. As a general rule, where buses are inclosed in compartments, the intervals between the supports along the bus are determined by the width of the adjacent oil circuit-breaker structure.

Salvaging Brass from Light Bulbs

BURNED out electric lamps, which the average householder throws into the ash can, are considered so valuable for salvaging purposes by The New York Edison Co. that a new machine called a rumbler has been perfected in the company shops to thresh the brass shells out of them.

Every year the company collects about 300,000 of these incandescent lamps from its offices, stations, and other places. Only the brass shells at the end, the part that screws into the socket, are worth saving, being sold as scrap metal.

Reclaiming this metal was formerly done by breaking the lamps by hand. They were put into a barrel, rigged like a churn, and a dasher worked up and down. Breaking the lamps in this way not only was slow and costly but too much material adhered to the brass shells, lowering their market value.

This new motor driven rumbler is a long, round machine. A revolving steel cylinder inside is perforated with many holes that are not quite large enough for the brass shells to fall through. About a barrelful of the glass bulbs, 300 to 500 of all sizes, is poured into the cylinder. Loosely placed among them are two long steel bars, which are covered with prongs.

As the rumbler revolves at high speed, these prongs quickly knock glass, filament, wires and even cement loose from the brass shells. The debris falls through the holes in the cylinder into a steel drawer and the brass shells, clean and bright, remain inside the cylinder.

ILLINOIS POWER & LIGHT CORP. offer to purchase the Princeton, Ill., municipal electric light plant for $600,000, including the water and heat utilities, is "advantageous," according to report submitted by Alvord, Burdick & Howson, engineers employed by a citizens' committee. The report estimates that the water and light plants will require $100,000 expenditures to put them in standard condition. The report contradicts the early one under which the council suspended negotiations with the Illinois Power & Light Corp.

Electricity---What It Is and How It Acts*

PART XXII. THE THREE ELECTRODE VACUUM TUBE. ITS PRINCIPLE OF OPERATION AND CONSTRUCTION. BY A. W. KRAMER

WE NOW COME TO AN application of the thermionic principle, which is of great significance not only because it forms the basis of the modern radio industry and has made possible transcontinental telephony but because it has given us a more thorough

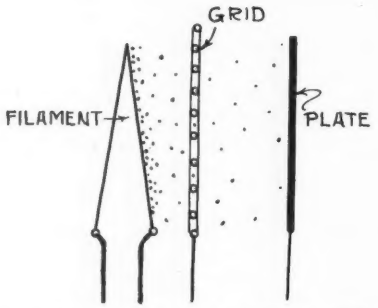


FIG. 1. THE ELEMENTS OF A THREE ELECTRODE VACUUM TUBE

understanding of electrons and their behavior than would have been possible without it. The application we have reference to is that made in the "three-electrode" vacuum tube.

The vacuum tubes we have thus far considered have had only two electrodes, one a negative electrode consisting of a hot filament and the other, a positive electrode consisting of a cold metal plate. This type of tube, we learned, can be used to rectify alternating current. The three-electrode tube which we are now to consider, differs from the two-electrode tube in that a third electrode, called a grid, is interposed between the filament and the plate for the purpose of controlling the plate current. The grid usually takes the form of a fine wire mesh or screen; the electrons passing from the filament to the plate must pass through the holes in the mesh and their passage to the plate is controlled to any desired extent by varying the potential of this grid. The usual arrangement is that shown in Fig. 1. It so happens that while the plate current may be of considerable magnitude and the amount of power quite high, the amount of energy necessary to effect its control by means of the grid may be extremely small.

In the previous articles, we have shown that the strength of the plate current (for a given filament temperature) is dependent upon the intensity of the electrostatic field set up by the potential difference between the filament and the plate. We also learned, in our study of the electric field,[1] that the force between two electric charges varies inversely as the square of the distance between them. In a given vacuum tube, therefore, for a certain plate potential it would be possible to increase the plate current by decreasing the distance between the filament and the plate.

Suppose that, instead of moving the plate closer to the filament, we place a grid in between the filament and the plate as shown in Fig. 1 and impart a slight positive charge to this grid by connecting it to the positive terminal of a battery. It is evident that this positively charged grid will aid the plate in drawing electrons to it. Since the grid is much closer to the filament, a much smaller positive charge is necessary to exert a given attraction than would be necessary by applying the charge to the plate. If, instead of charging the grid positively, it is given a negative charge, the electrons emitted by the filament will be repelled by the negative charge on the grid and a smaller proportion of them will reach the plate. If the negative charge is increased, the effect of the positive charge on the plate may be neutralized entirely, reducing the plate current to zero.

TUBE FUNCTIONS AS A RELAY

This is a simple explanation of the function of the grid in the three-electrode vacuum tube. The tube in fact is a relay. In Fig. 2 is shown a simple relay. When the magnet M is energized by weak current from the battery B, due to the key K being closed, the armature A is attracted downward. This closes a pair of contacts C one of which is carried by the moving armature A, thus permitting current from the local battery

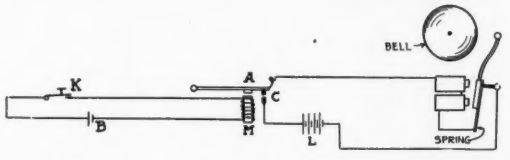


FIG. 2. A SIMPLE RELAY OPERATING AN ELECTRIC BELL

L to flow in the bell circuit. In this way a large bell requiring comparatively heavy current, can be operated from a distant source by a current too weak to operate the bell direct. In this analogy, the magnet M corresponds to the grid in the three-electrode vacuum tube. The vacuum tube is a much more sensitive relay than any mechanical relay ever constructed, for the simple reason that the moving parts (the electron stream) have no inertia.

To understand fully the factors that control the action of the three-electrode vacuum tube, it is necessary to investigate its action more in detail.

MORE CONCERNING THE SPACE CHARGE

In one of the previous articles,[2] brief mention was made of the so-called "space charge." This, it may be recalled, was the negative influence of a cloud of electrons in the immediate vicinity of the hot cathode. The three-electrode vacuum tube functions because of the effect of the grid on the space charge in the tube or to express it in another way, because of its effect on the potential distribution between the filament and the plate.

*All rights reserved.
[1]Part VI, August 1, 1928 issue, page 825.
[2]Part XX, March 15, 1929 issue, page 361.

In previously considering the action of the vacuum tube, it was assumed, or rather nothing was said about it, that the potential gradient between the filament and the plate is uniform. Actually, this is not true. The gradient is less near the filament, for two reasons: first, because of the comparatively small surface of the filament with respect to the plate, and second because of the electron cloud surrounding the filament.

In Fig. 3 is shown a diagram illustrating crudely, the relative distribution of electrons between the hot filament F and a plate P carrying a positive charge. As already explained, the density of electrons is considerably greater near the filament than it is near the plate, due to low velocity electrons falling back into the filament. Now let us consider the forces acting on two electrons, one at A, close to the filament and another, B, near the plate. The one at B is urged toward the plate by two forces: first, the attraction of the plate and second, the repulsive effect of all the electrons

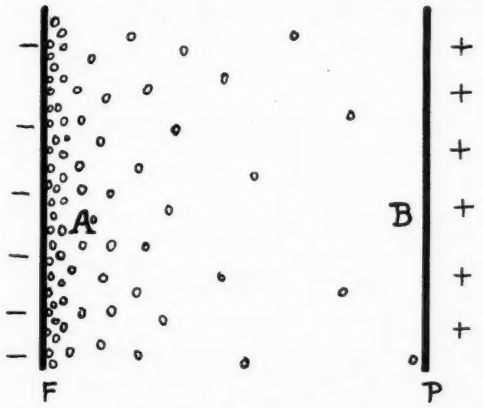


FIG. 3. DIAGRAM SHOWING THE DISTRIBUTION OF ELECTRONS BETWEEN THE FILAMENT AND PLATE OF A VACUUM TUBE

An electron at B is not only urged to the plate by the attraction of the positive charge but is also by the repulsion of all the electrons in the space between it and the filament. An electron at B, however, although it may be attracted by the plate, is repelled in the opposite direction by all the electrons between it and the plate.

between it and the filament. The electron at A is also acted upon by two forces, first the attraction of the plate and second the repulsive effect of all the electrons between it and the plate. In this case, however, the repulsive effect of the electrons is opposite to the attractive effect of the plate and whether the electron at A will move toward the plate or the filament will depend upon which of the two forces is stronger. Very close to the filament, the combined repulsive effect of all the electrons between the filament and the plate will practically neutralize the attractive effect of the plate unless the plate voltage is high enough to give an attraction greater than the repulsive effect exerted by the space charge. From this it is evident that the potential distribution in a vacuum tube is not uniform but is less near the filament than it is near the plate.

Effect of Potential Gradient on Electrons

To make this more clear, consider the potential gradient between two cold metal plates, shown by the straight sloping line a in Fig. 4.[3] Here the potential gradient is uniform as would be expected.

[3] J. H. Morecroft, Principles of Radio Communication, p. 458.

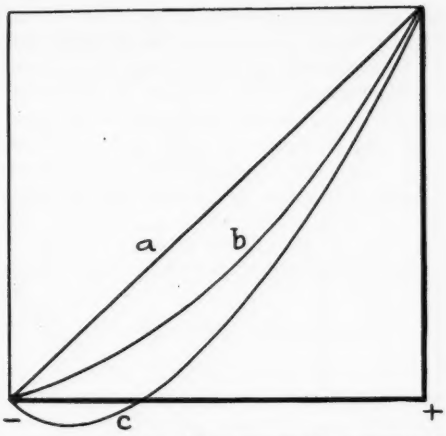


FIG. 4. DISTRIBUTION OF POTENTIAL BETWEEN TWO PLATES UNDER VARIOUS CONDITIONS

a represents the potential gradient between two cold metal plates. b is the potential gradient curve when the negative plate is surrounded by electrons. c represents the potential gradient when the electron emission is considerably greater than the plate current.

Suppose, however, that electron atmosphere is made to surround the negative plate by heating it to a high temperature. Many of the lines of electrostatic force formerly (when no electron cloud existed) extending from the positive plate to the negative plate, will now terminate on electrons near the negative plate. Thus, many of the lines leaving the positive plate never reach the negative plate. This is shown in Fig. 5. Under these conditions, the potential distribution curve instead of being a straight line as shown in Fig. 4, a, takes the form shown in b. If the electron emission is much greater than the plate current as is usually the case in ordinary vacuum tube operation, the potential very close to the surface may even become negative, resulting in the curve shown in Fig. 4c.

Now, by placing a grid between the plates and charging this grid positively or negatively, the shape of the curves b can be changed. This is shown in Fig. 6. If the grid is not given any charge, it will exert no effect and the curve representing the voltage gradient will be as at a.

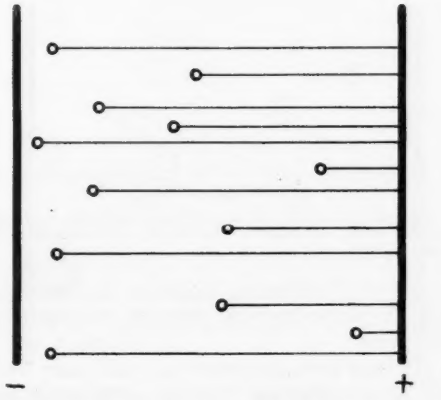


FIG. 5. DIAGRAM SHOWING WHY THE POTENTIAL GRADIENT IS LOWER NEAR THE FILAMENT THAN IT IS NEAR THE PLATE

Lines of force extending from the positive plate, terminate on electrons in space instead of on the filament. There are thus more lines of force entering the positive plate than the filament.

If the grid is made positive, however, the potential gradient in the space between the negative plate and the grid, is greatly increased. Many low velocity electrons which, without this increase of potential, would have fallen back into the negative plate without the additional field set up by the grid are now drawn away toward the grid. What really has occurred is that the space charge has been neutralized to a considerable extent.

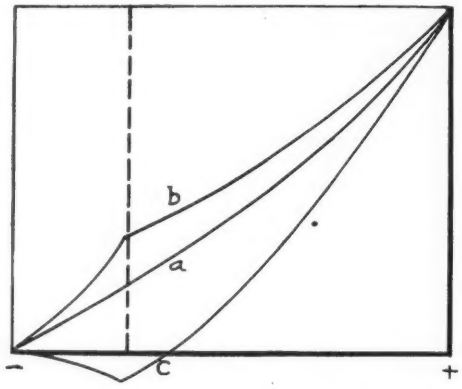


FIG. 6. SHOWING THE EFFECT OF THE GRID ON THE POTENTIAL DISTRIBUTION IN A TUBE

a is the potential gradient curve with the grid uncharged. b shows the gradient with a positive charge on the grid and c with a negative charge on the grid.

The electrons which are thus drawn to the grid are now acted upon by the combined attractive force of both the grid and the plate. As an electron approaches the grid, it has two alternatives: it may attach itself to the grid, thereby neutralizing one of the positive charges on the grid, or it may pass through one of the holes in the grid and continue on to the plate. A comparatively

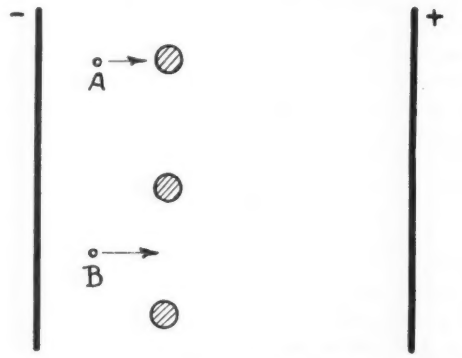


FIG. 7. POSSIBLE POSITIONS OF ELECTRONS IN A THREE ELECTRODE TUBE

The electron at A is almost certain to pass into the grid. The electron at B, although attracted by the grid will continue on to the plate.

small number of electrons do attach themselves to the grid but the majority pass through the openings and go to the plate.

An electron moving toward the grid may find itself in either of two positions: it may be traveling on a line which passes directly through one of the wires constituting the grid, as at A, Fig. 7, or it may be moving along a line passing between the grid wires, as at B, Fig. 7. If it happens to be the former, the chances are that the electron will go to the grid since there are no forces acting to make it deviate from its straight course. In position B, however, the electron will certainly continue towards the plate, because of the higher potential and greater surface of the plate. Thus, the introduction of a positively charged grid between the filament and the plate will cause more electrons to reach the plate than would be the case without it. The positive grid has the effect of reducing the space charge and changing the shape of the potential distribution curve to that shown in Fig. 6b.

If the grid is given a negative charge, however, electrons emitted by the filament will be repelled by the negative charge on the grid and practically none of them will reach the plate. Under these conditions, the potential distribution curve will assume the character of C in Fig. 6. The point to be kept in mind in visualizing the action of the three-electrode vacuum tube is that the grid potential necessary to control a large plate current is small.

From the above explanation, it will be evident that any variation in the potential of the grid, will effect a

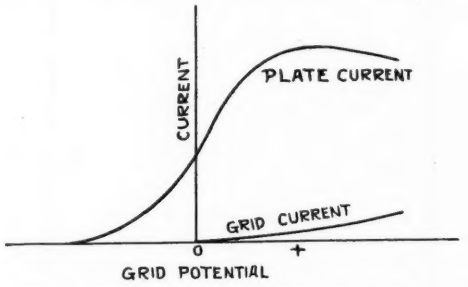


FIG. 8. CURVE SHOWING VARIATION OF PLATE CURRENT WITH GRID POTENTIAL

corresponding variation in the plate current. If the grid potential is increased (positively) the plate current will increase; if it is reduced, the plate current will be reduced. If the grid is made negative, the plate current will decrease still more and at a certain negative grid potential the plate current will fall to zero.

Figure 8 shows the variation in plate current with grid potential, for a given plate potential. As may be noted, as the grid potential is varied from negative through zero to positive, the plate current gradually increases until the saturation current[4] corresponding to the filament temperature is reached. As the grid is made increasingly positive, a greater number of electrons will be attracted to the grid, resulting in a slight *grid current* with a corresponding slight drop in plate current. It is evident that the production of a grid current is done at the expense of the plate current.

How a Three-Electrode Tube Amplifies

Suppose, now, that instead of merely applying a positive or negative potential to the grid, an alternating potential is applied; what will be the result? In Fig. 9, an attempt is made to show this. A definite steady negative voltage is first applied to the grid by means of a small battery, C, in Fig. 10. This gives a definite operating point P on the plate current-grid voltage curve, Fig. 9. A small alternating voltage Eg is superimposed on this steady voltage by connecting a source of alternating voltage, as shown in the circuit diagram,

[4]See Part XX, March 15, 1929 issue, p. 358.

in the grid circuit. With such an arrangement the grid voltage will vary as shown between Eg1 and Eg2. Since each variation in grid potential produces a corresponding variation in the plate current, the wave e_g may be projected vertically to the curve PC and then horizontally producing the wave Ip. Thus, the introduction of an alternating potential in the grid circuit

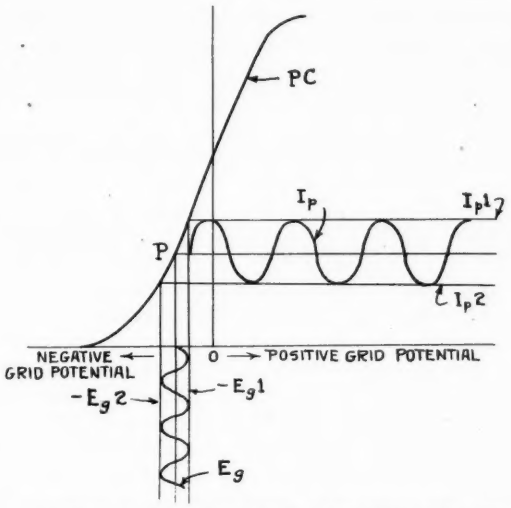


FIG. 9. DIAGRAM SHOWING THE AMPLIFICATION CHARACTERISTICS OF THE THREE ELECTRODE VACUUM TUBE

Eg is the alternating potential impressed on the grid. Ip is the alternating current produced in the plate circuit.

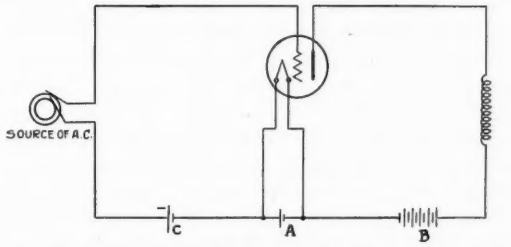


FIG. 10. CIRCUIT USED TO PRODUCE CONDITIONS SHOWN IN FIG. 9

results in the production of an alternating current in the plate circuit which is superimposed on the steady plate circuit due to the battery B in Fig. 10. This alternating current may be considered as being produced by a voltage $f_a e_g$ acting through a constant plate resistance rp. In this expression, the term f_a is called the amplifying factor of the tube. It will be noted that the alternating current in the plate circuit varies between much wider limits than does the alternating voltage in the grid circuit. This, of course, is due to the steepness of the slope of the curve PC.

A three-electrode vacuum tube, therefore, may be made to function as an amplifier of alternating current and in this capacity it has received great application in the radio field. From the diagram shown in Fig. 9, it will be evident that the voltages Eg1 and Eg2 should be selected so as to compel the alternating current to operate on the straight part of the characteristic curve. If the point P, for instance, had been moved down lower on the curve, the resultant alternating current in the plate circuit would no longer be symmetrical and a distorted wave would be produced. The point P can be moved anywhere along the length of the curve PC by merely impressing the proper grid voltage on it. This, in radio circuits, is usually done by means of what has come to be known commonly as a "C" battery. The more technical designation is the grid bias battery.

In modern three-electrode tubes, the amount of power taken by the grid is so small that the power in the plate circuit which it controls may be thousands of times as great. Certain tubes used as amplifying repeaters have power amplifications of about one thousand times.

The Telephone Repeater

This particular application of the three-electrode tube is of considerable interest. In an ordinary tele-

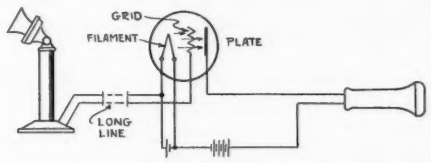


FIG. 11. SHOWING THE PRINCIPLE OF THE TELEPHONE AMPLIFIER

phone line, the voice current falls off in intensity very rapidly as the length of the line increases. For local communication, this is not a serious matter but for long distance telephoning it is a limiting feature. To overcome, or rather to counteract this effect today, amplifying repeaters are placed in long distance lines at definite intervals. In Fig. 11 is a diagram showing

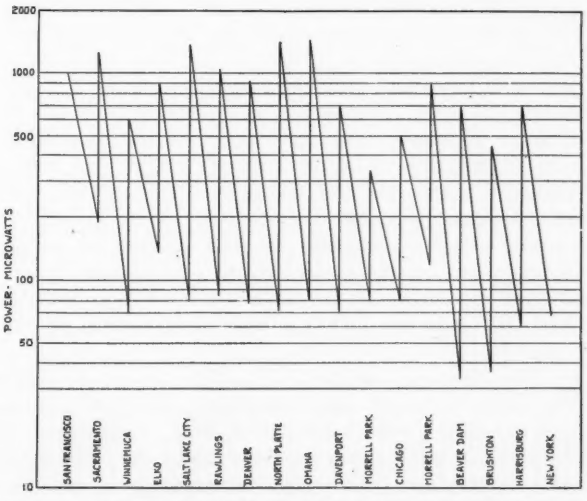


FIG. 12. POWER LEVELS OF SAN FRANCISCO-NEW YORK TELEPHONE LINE, SHOWING EFFECT OF REPEATERS

With 1000 microwatts input at San Francisco, the power drops to slightly under 200 mw. at Sacramento. Here the current is amplified by vacuum tube repeaters to a value of over 1000 mw. This new high level falls to 70 mw. by the time it reaches Winnemuca where it is again amplified. Thus, the voice current is amplified successively 15 times before it reaches New York City.

how the value of the voice current decreases in intensity and how it is amplified by vacuum tube repeaters along the transcontinental telephone line. In this way, the intensity of the voice current can be controlled to any desired extent, the received current at New York often being higher than it was when it left San Francisco. At

each repeater station, the gain in intensity is effected by an addition of power supplied from local batteries. The principle is the same as that illustrated in Fig. 2 where a weak current is made to ring a powerful bell through the relay. The three-electrode vacuum tube is an amplifying relay.

It is of interest to know that, without the repeater, transcontinental telephony would be virtually impossible. For instance, on the San Francisco-Havana line, with the transmitter delivering 1000 microwatts at San Francisco, the power delivered at Havana at the end of the 5500-mi. circuit is about 25 microwatts. If there were no intermediate amplifiers and assuming that the line could carry unlimited power without burning up, it would be necessary, in order to deliver 25 microwatts at Havana, that power sufficient to light an ordinary incandescent lamp would be flowing in the circuit at some point in North Carolina while at Philadelphia the power would be 5 kw. A little east of Denver the line would be carrying the equivalent of all the electrical and mechanical power generated in the world (enough to light 20 billion electric lamps). This is about 1/200,000 of the power which is received by the earth from the sun. Yet at Sacramento all of this power (200,000 times all the power generated on earth) would have to be flowing in the line to produce 25 microwatts at Havana.[5]

[5] H. S. Osborne, Telephone Transmission Over Long Lines. Proceedings of the A. I. E. E., Vol. XLII, p. 984.

Practical Methods of Oxy-Acetylene Welding

PART I. USE OF THE TORCH IS BECOMING A NECESSARY TRADE FOR THE ENGINEER. PRECAUTIONS AND DIRECTIONS ARE GIVEN FOR USE OF EQUIPMENT. BY L. A. COWLES

OF NECESSITY, the engineer is the most versatile of all tradesmen. Many engineers are increasing their value to their employers and to themselves by taking advantage of the oxy-acetylene torch in their work. Not only does this reduce their costs materially but it also is conducive to continuity of operation and creates a new interest in their work.

Oxy-acetylene welding is not at all difficult. Any mechanic will develop as a first class welder in a short time, if he is willing to study the subject. The author suggests the study of welding first from one of the many excellent textbooks published or from instructions sent out by the manufacturers of welding equipment; second, by practice under the instruction of an experienced welder. Practically all companies selling such equipment will send a man when new equipment is put in. This is, of course, the best way to learn welding as you are assured competent instruction from one who is principally concerned in seeing that you get the most out of your equipment.

Oxy-acetylene welding is often spoken of as gas welding, but as this might lead to applying the following instruction to any gas used by a torch, it is probably best that only oxy-acetylene and oxy-hydrogen be considered.

For rapid and economical welding the oxy-acetylene flame has points of superiority over many other gases for all welding except sheet metal work. Hydrogen has only one advantage over acetylene and that is in cutting very thick pieces. It is then far superior to acetylene because of the long flame and its non-oxidizing properties which results in smoother cuts. The flame temperature of oxy-acetylene is 6300 deg. F., while oxy-hydrogen is 4100 deg. F.

Welding as accomplished by any method is the joining of two parts by fusion of the metals. They may or may not be of the same characteristics. Welding cannot be compared to soldering because it involves the melting of the metal in the parts and usually requires the fusion of additional metal between the parts to be joined. This material may or may not be of the same composition as the pieces to be welded.

Forge welding, which is the heating of two metals to a plastic condition and hammering them together, is not comparable to the fusion process, because of its uncertain strength and its limitations. Much of the negative attitude toward oxy-acetylene welding is due to past experience with forged welds.

Oxy-acetlyene and forge welding have some things in common; i.e., the use of flux, heating the metal and hammering. An oxy-acetylene weld of steel is strengthened by judicious use of the hammer, but this working the weld is frequently impossible and seldom necessary. Forge welding is limited to wrought iron and steel, while the fusion method has no limitations. I shall use the descriptive word "fusion" instead of the ancient word "welding" because fusion is the actual essential feature of the process.

Although simple in construction, the torch used for the fusion of metals is a precision instrument. The essential features are the mixing chamber, the tip and the valves controlling the flow of the gases. The high temperature secured by combustion of the gases (6300 deg. F.) is produced at the tip. The engineer will readily see the necessity for correct gas mixture in such proportions that combustion is complete. This is not only conducive to economy in gas consumption but a neutral flame is essential to a good union of the metals.

Metals are especially susceptible to chemical reaction when subjected to heat and they have a particular affinity for oxygen. This oxygen may come from the torch or the air and any excess will unite with the metal to form an oxide. As this weakens the weld, care must be taken as to the adjustment of the torch flame. Any excess of acetylene, as this gas is rich in carbon, will cause the metal to become hard and brittle.

Composition of the metal adjacent to and throughout the union may be changed, as tempered steel will cease to be hard after melting. The welded portion will be cast steel. Brass or bronze may be changed in character as some alloys are melted out and it may become porous due to oxidation. Cast iron frequently becomes brittle. The above-mentioned conditions can be guarded against by the proper selection of welding rod, flux, the manipulation of the torch and careful cooling.

For the average size plant, a medium sized torch for

welding and a general all-around cutting torch can be purchased complete with reducing valves, hose and connection, welding rods, flux, goggles and instruction book for approximately two hundred dollars. Combination welding and cutting torches are on the market costing slightly less than the separate welding and cutting torches. Attachments can also be obtained for changing a welding to a cutting torch.

There are a few points in a torch that one should always consider: balance and weight, valves, hose connections and the number of tips. The torch should consume about equal amounts of acetylene and oxygen, although the author has never found a torch with a perfect fifty-fifty gas consumption. The design controls the gas velocity, and may explain the flash back (burning in the tip) and a general gatling gun disposition.

The supply of gas is well taken care of by the manufacturers, with points of distribution throughout the country. The gas is shipped in and used out of cylinders which are rented or loaned to the consumers. The rental charge is low and includes upkeep. No charge is made for the first 30 days and usually only 25 cents a month thereafter until the empty is returned. If sufficient gas is used there will be no rental charge. Three-day service can be expected in practically any part of the United States.

Since the regulating valves or reducing valves control the gas pressure to the torch, therefore the flame, they are very important. Some welders adjust the flame with the torch valves, but this practice is not recommended.

The oxygen cylinder carries oxygen at a pressure of 1800 to 2000 lb. per sq. in. It is advisable to handle this cylinder with care. If by any chance a cylinder under 2000 lb. pressure should burst, the result would be equivalent to an explosion. The warning printed on the cylinders, "Use no oil," should be carefully followed or a bang may result. This might ruin the regulator and, incidentally, the engineer's disposition. No lubricant other than soap should be used for the connections and all parts should be kept clean.

Acetylene

Acetylene is very explosive when compressed above 20 lb. For this reason it can be used in only two forms: stored in cylinders designed for this purpose and in the form of calcium carbide which produces acetylene when brought in contact with water. Acetylene is soluble in a number of liquids, among them acetone. As acetone is incombustible, inert and dissolves 24 times its volume of acetylene, it is the standard solvent. The pressure of an acetone-acetylene combination in a cylinder is doubled with every 30 deg. C. rise in temperature. For this reason the cylinder should not be subjected to heat as the pressure may rise to a dangerous point.

Due to the increase of volume in acetone (300 volumes of acetylene increases the volume 50 per cent), the cylinders are filled with a porous substance, usually asbestos fibre, and some binder saturated with acetone. This prevents the formation of voids as acetylene is used. The cylinders should always be kept in an upright position and jarring them should be avoided as this might displace the porous filler. It might seem unnecessary to warn against an attempt to weld an acetylene cylinder, but one man tried it and his friends never found enough of him to bury.

Do not test for leaks with a flame, but use your nose. If a leak develops, do not use the equipment until the leak is stopped. Cleanliness is conducive to long life and efficiency.

All parts should be blown out with air before any connections are made because any foreign matter may injure the reducing valve and stop up the passages in the torch. A short hose is usually used in welding shops, but around the plant a 30-ft. hose is about right, enabling one to cut out boiler tubes, and weld splits or pin holes. Often the torch is found convenient for heating a bag in a tube to be driven back with a flatter. Repairs to breechings, pipe lines, etc., also require a long hose. Different colored hose for the two gases will prevent mistakes in connecting.

The regulators, or reducing valves, are first attached to their respective cylinders. No difficulty should be experienced in getting the right regulator on its cylinder, the acetylene cylinders and regulators having left-hand threads. The oxygen high pressure gage is calibrated considerably higher than the acetylene. The torch is then connected to the regulators with the hose and you are ready to test for leaks, using soap suds. The adjusting screws on the regulator should be slacked off (set for low pressure) and the cylinder valves turned on very slowly so as not to injure the regulator. The gas pressure can now be adjusted by means of the regulator to that specified by the manufacturer for the torch.

(To be continued)

Clarence S. Macy, president of the Iowa section, N. E. L. A., presiding at a recent meeting of the section, stated that Iowa has 99.7 per cent of its urban population in towns and cities served by electricity and said that millions had been spent during 1928 in extending and improving the electric facilities. Generating capacity has been increased, between 700 and 800 mi. of new high-voltage transmission lines built into new territory and inter-connecting towns to assure reliable service; while hundreds of local lines have been rebuilt and modernized.

There are now 13,817 farms in the state connected up with central power stations with 14,000 additional farms having individual electric plants, giving 13 per cent of the farms electric service. Iowa kilowatt production last year increased 95,000,000 kw. to a record total of 1,506,000,000 kw. and customers increased from 407,000 to 417,240. Mr. Macy called attention to the distinct trend in the state toward consolidation based upon economic reasons as result of improvements which give the larger plant two and often three times the energy from the same amount of fuel as the small plant, no matter how economically the latter is operated, while union of plants provides two and three-way service, insuring these communities with cheaper and more dependable service than ever before.

New England Power Co., Worcester, Mass., is reported to be planning a new steam power plant in the vicinity of Millbury, with initial capacity of about 50,000 kw.

Philtower Building in Tulsa Burns Gas

THREE 150-HP. HEATING BOILERS, HOT WATER BOILER, WATER SERVICE AND DIFFERENTIAL HEATING SYSTEM FEATURES OF NEW 24-STORY BUILDING

AS AN IMPORTANT UNIT, serving the varied industrial and business demands of the growing city of Tulsa, Oklahoma, the new Philtower Building presents mechanical and electrical difficulties somewhat different from the usual office building in the north, where the more rigorous winters and longer heating season often justify automatic equipment and generation of electrical power.

Here the comparatively short and mild heating season precludes any possibility of economical electric power generation with high back pressure units, so the

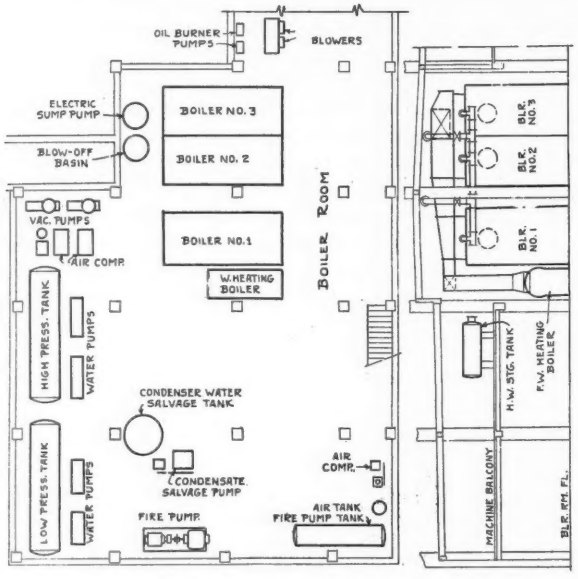


FIG. 1. GENERAL PLAN OF THE BASEMENT FLOOR AND SECTION SHOWING THE GALLERY

well-designed plant has been laid out to meet best the present elevator, general service and heating needs of the building and allow for future expansion.

In Fig. 1, the general plan of the basement showing the location of the boilers, pumps and compressors can be seen. Naturally, purchasing electric power from the local public utility company, and with little or no use for exhaust steam, all of the equipment is motor driven.

On the basement floor are located the boilers, air compressors, vacuum pumps and general service pumps, while the drinking water cooling equipment, drinking water pump and purifier, water heaters, incinerator, transformers, switchboard and instrument board are located on a gallery, shown in section, which overlooks the major portions of the basement.

On this gallery, immediately in front of the instrument board, is located the operating engineer's desk and from this point of vantage, the boilers and most of the equipment are visible. On the instrument board are mounted Foxboro indicating and Brown recording gages, showing the various air and water pressures and a Brown recording CO_2 meter. Electric power is brought into the building through the power company transformers to a Frank Adams Electric Co. black slate and steel 125 and 250-v. switchboard equipped with Condit circuit breakers, a Westinghouse demand meter and General Electric instruments.

DIFFERENTIAL HEATING SYSTEM INSTALLED

Steam for heating is furnished by three Heine 1517-sq. ft., 165-lb. water-tube boilers each with 85, 3½-in., 18-ft. tubes. Bayer soot blowers are installed. Steam for the heating of domestic water is furnished by one 50-hp. Kewanee portable type boiler. Three Excelsior water heaters, shown in Fig. 2B are provided, one on the low pressure system (up to and including the eleventh floor) one on the high-pressure system (above the eleventh floor) and a third so installed and piped that it will serve as a spare for either of the other two. The piping arrangements are shown in Fig. 4. Temperatures are maintained constant by Powers thermostatic regulators.

For heating, the Dunham differential system is used, the two size D vacuum pumps, driven by 3-hp. motors, being visible in the background of Fig. 2D. Owing to the fact that this is a monumental type building with step-backs at various floor levels, it was considered more economical to use an upfeed rather than the usual downfeed system for steam heating.

With this arrangement, however, the building is divided into two levels, all floors up to and including the eleventh being supplied with steam from mains in the basement ceiling. The main supply and return risers are run up to the eleventh floor with mains and branches located in the attic space above the eleventh floor to feed all radiators from the twelfth floor up.

All supply and return risers throughout the building are concealed in pipe cases or are concealed with metal lath and plaster. Branches from risers to radiators are also enclosed or concealed in the false ceiling construction with only stubs through the floor to the radiators showing. All radiators are suspended on wall brackets. Automatic temperature regulation was not installed because it was felt that, in the mild climate, there would not be sufficient saving to justify the investment.

High-pressure boilers were installed with the low-pressure heating system because it was believed that a water-tube boiler would outlast two or three sets of low-pressure heating boilers and that the difference in cost would be paid for during the life of the plant. Furthermore, the engineers thought that a boiler of the type installed could be operated at from 100 to 150 per cent overload and take care of additional load that might be added in the future.

Gas metered by Westcott and Pittsburgh meters is used as fuel in all boilers, with oil as a standby. Two

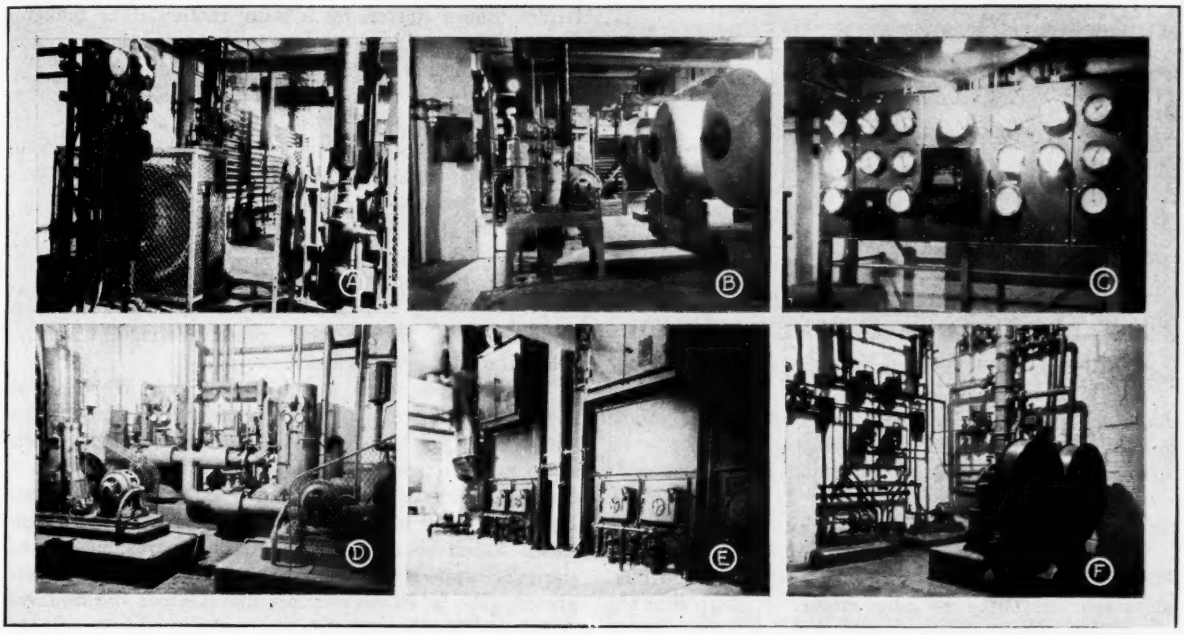


FIG. 2. VARIOUS EQUIPMENT INSTALLED IN THE BUILDING: A, REFRIGERATING MACHINE FOR COOLING WATER; B, HOT WATER HEATERS; C, INSTRUMENT BOARD; D, AIR COMPRESSORS AND HEATING SYSTEM PUMPS; E, BOILERS; F, BLOWERS AND COMBUSTION CONTROL APPARATUS

Anthony combustion oil and gas burners are installed under each of the three boilers, so that it is possible to burn both gas or oil at the same time if necessary. Figure 3 shows a cross section of the furnace and the arrangement of the equipment. Automatic combustion control, Figs. 2F and 5, consisting of Powers diaphragm valves is installed, variations in pressure in the steam header being used to control the rate of fuel feed and maintain a constant pressure. American blowers for oil atomization are in duplicate for the large units, with one small blower for the heating boiler. Two Viking fuel oil pumps handle the fuel oil.

Drinking water, circulated by two Goulds triplex pumps, driven by 3-hp. motors, is cooled to 40 deg. F. by a Worthington-Carbondale Size VD refrigeration. The compressor is driven by an Ideal 15-hp. 220-v. synchronous motor with overhung rotor, as shown in Fig. 2A. Cooling water for the double-pipe condenser is taken from the city mains and after passing through the condenser is stored in a storage tank for use in the domestic water system. Drinking water is sterilized by a 6.6-g.p.m. R.U.V. ultra violet ray treater and filtered through a Bowden, size 4, single-valve filter.

Two large storage tanks with duplicate Goulds centrifugal pumps for supplying domestic water to the building are shown in Fig. 1. One of these units with three stage pumps driven by 15-hp. motors supplies water up to and including the eleventh floor, while the other with four-stage pumps driven by 25-hp. motors, supplies the upper floors.

Air pressure is maintained on these tanks by a

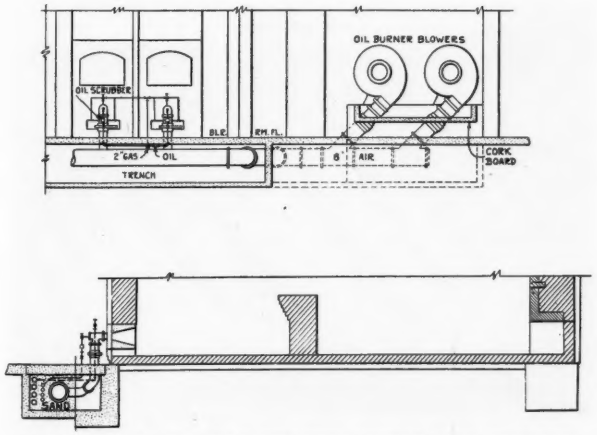


FIG. 3. OIL AND GAS BURNER PIPING AND SECTION THROUGH THE FURNACE

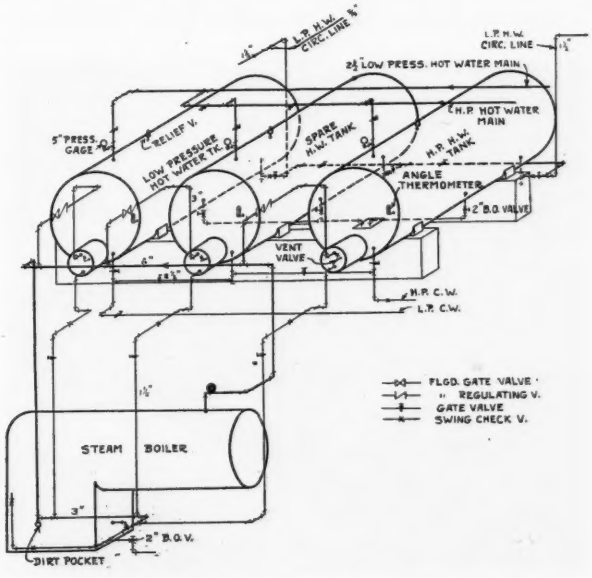


FIG. 4. ISOMETRIC SKETCH SHOWING THE PIPING OF THE HOT WATER STORAGE HEATERS

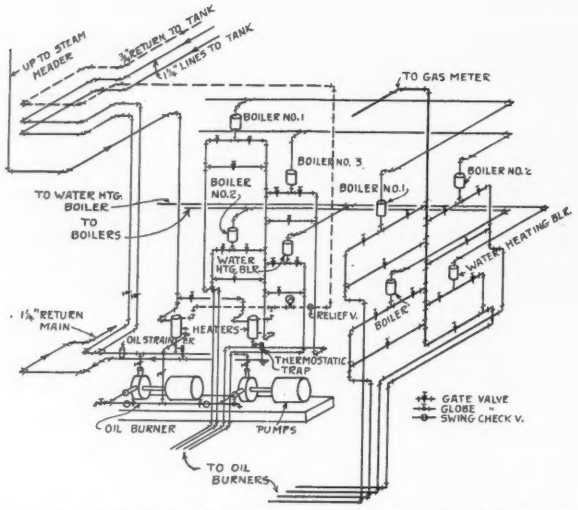


FIG. 5. DIAGRAM OF THE PIPING SHOWN IN FIG. 2F.

Gardner-Rix 4½ by 2 by 4½-in., 600-lb., 500-r.p.m. compressor driven by a 7.5-hp. motor. Makeup into the system is handled by an automatically controlled Goulds triplex pump driven by a 5-hp. motor. The makeup water is obtained from the storage tank for the ammonia condenser discharge water.

A Goulds 750-g.p.m., 200-lb. Underwriters fire pump driven by a 150-hp., 1750-r.p.m. motor starts automatically if pressure in the tank drops below a certain value. This pump is controlled by a Cutler-Hammer automatic control panel.

For ventilating the basement and store rooms, a ventilating and exhaust system is installed. This consists of a Reed air filter and two Sirocco fans driven by 2-hp. motors. The small machine shown in the foreground of Fig. 2B is a small general refrigerating unit belonging to a nearby florist shop.

In addition there are installed two Worthington 4½ by 5-in. single stage compressors used for opening and closing the elevator doors and a Yeomans vertical sump pump driven by a 5-hp. float controlled motor.

The Philtower building is owned by Waite Phillips. Keene & Simpson and Edward Buehler Delk were associated architects. Walter E. Gillham was mechanical engineer and Hans VonUnwerth was structural engineer. W. L. Dixon is superintendent of the building and Louis H. Moses is engineer.

How Alabama Power Co. Uses Models to Predict Performance of Hydraulic Structures

MANY MONTHS before its hydroelectric developments are completed, the engineering department of Alabama Power Co. can safely predict what effect every foot of water that passes over a development will have on the structure and how much power it will develop. That statement may sound far-fetched but it is literally true, for the engineering department operates a hydraulic laboratory in which models of the developments are built and the water tests applied tested with extremely accurate results. I. A. Winter is head of the laboratory division of the engineering department, which has work rooms in a small building on Avenue F, South, in Birmingham, Ala.

According to a recent statement by Mr. Winter in Powergrams, the activities of the hydraulic laboratory division of the engineering department are many and varied. Every type of problem—from air tunnels to 20-ft. expansion joints—finds its way to this department for solution. The major work, however, has to do with specific problems in hydraulics. Now and then, of course, conditions arise which cannot be handled with the limited equipment and personnel available at the Birmingham laboratory and, in such cases, investigations are conducted at the larger laboratories in the East, under the direction of the Alabama Power Co. hydraulics staff.

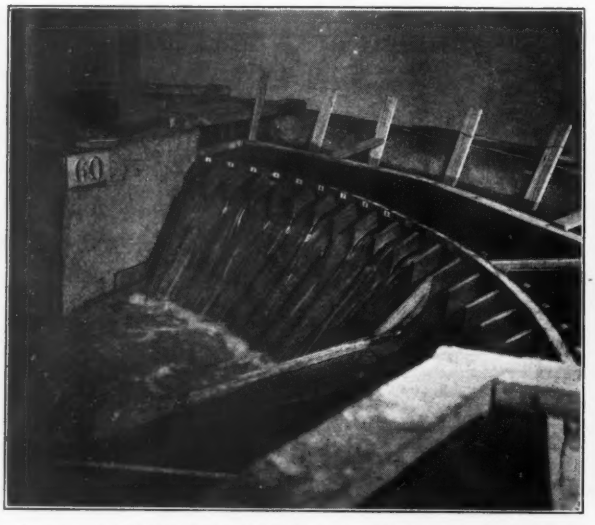


FIG. 1. LABORATORY MODEL OF MARTIN DAM UNDER TEST TO SHOW FLOOD WATER CONDITIONS

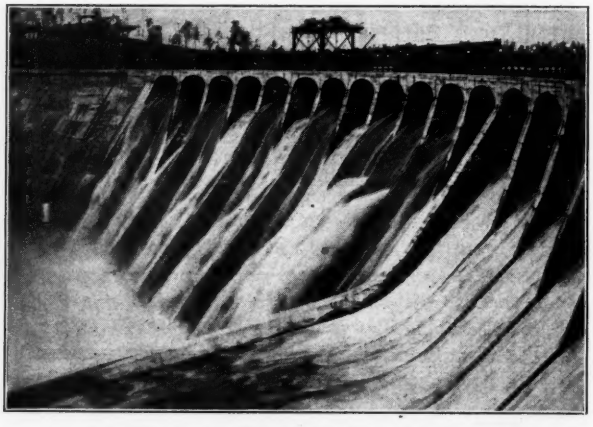


FIG. 2. MARTIN DAM ITSELF DURING THE FLOOD WATER CONDITIONS OF THE SPRING OF 1928

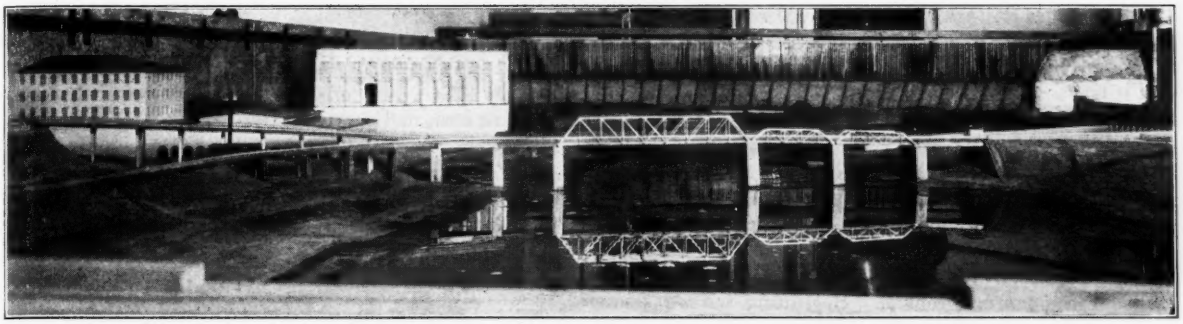


FIG. 3. LABORATORY MODEL OF LOWER TALLASSEE PROJECT

Although hydraulics is one of the oldest sciences, there is still comparatively little known as to the losses in flowing water. This lack of knowledge can be overcome, however, by the construction of models to a small scale which will indicate clearly and faithfully the performance of a full size structure. This is true only when all associated parts are correctly represented on the model. The skill of the experimenter is shown by his correct observation of the phenomena and his ability to secure consistent data.

To reduce the model to a working scale, it is frequently necessary to use wide ratios. The model of the Mitchell Dam backwater suppressor was 1/24 of the actual size of the structure. The model dam was faced with galvanized iron to represent the irregularities to be expected on good concrete. This factor has been proved by actual operation at Mitchell Dam, where results have been exactly as predicted by the model.

Actual Performance Checks Model Tests

Martin Dam development* presented several interesting problems which were worked out satisfactorily in the small model before the dam was constructed. It was necessary to construct this model, Fig. 1, to a scale of 1/100, to study the spillway conditions at the plant. In addition to the complete spillway, consisting of 20 gates, it was necessary for the laboratory to reproduce the equivalent of 1000 ft. of river bed below the dam. By the use of this model, it was possible to design the spillway aprons so that the destructive action of the flood water on the river bed was reduced to a minimum.

In the spring of 1928, a flood of 60,000 cu. ft. per sec. passed over Martin Dam, as shown in Fig. 2. The stilling basin and banked spillway were given a thorough test at that time and the structure proved a complete success, working exactly as predicted in the 1/100 model.

Tallassee Falls development represented the second backwater problem to be investigated. In this case a 1/100 model was constructed representing the complete development, Fig. 3, with sufficient river bed below the dam to determine a true backwater curve. The balance between cost of concrete penstock and tailrace excavation called for the power house to be located half way up the rapids. The best data available as to the correct elevation of backwater at this location called for a height of concrete substructure considerably greater than was anticipated. The model, however, gave the corect height at 15 ft. lower than the records, netting a saving of 15.5 ft. in the height of the power house substructure. Many other problems have been handled on this model, such as coffer dam heights for construction and probable flood elevation affecting adjacent structures.

*"Martin Dam Aids Control of Alabama System," Power Plant Engineering, March 1, 1927.

Value of Model Tests

Small models of this type are kept in the laboratory throughout the construction period of the project. It is gratifying to be able to reproduce a flood of any magnitude up to 200,000 cu. ft. per sec. as desired, without waiting 25 to 50 yr. for Nature to furnish the necessary water.

Every development has its specific problems and by persistent study and experiments made in this laboratory better efficiencies are being obtained by the power company for its newer developments. In addition to the improved efficiencies, simpler and more economical structures are being developed. Every new hydroelectric development has improvements over the ones that were built before.

Many factors enter into the economics of a large hydroelectric system. Among the most important are specific hydraulic data. The laboratory is the only place where such information can be obtained, as the physical dimensions of the actual large structures make investigations extremely difficult and expensive.

By the use of models, spillway coefficients can be obtained to a high degree of accuracy, turbine efficiency can be determined, water passages can be altered and improved, backwater curves can be established, treatment of spillway aprons for discharge can be determined, gate pressures and operations can be estimated and numerous other associated problems can be worked out in a satisfactory manner.

El Paso Electric Co., El Paso, Texas, has acquired a tract of about 70 acres of land as a site for a new steam-operated electric power plant, for which plans will be prepared at an early date. It will be equipped for an initial capacity of 55,000 kw., and is reported to cost close to $4,500,000, including transmission lines and switching stations. The work will be carried out by the company in connection with a 1929 expansion and betterment program to approximate $5,500,000, the remainder of the fund to be used for other transmission line work, distributing system extensions, power substation, and general improvements in service facilities. The company is operated by the Engineers Public Service Co., which is an interest of Stone & Webster, Inc., Boston, Mass.

Superiority of Factory Generated Power

ANALYSIS OF COSTS AND CONDITIONS THAT LED TO COMPLETE DISCONTINUANCE OF BUYING ELECTRICAL POWER. BY F. S. RUTLEDGE

STARTING IN A SMALL way and gradually increasing, developing and perfecting its organization, the plant in which I am employed has, during a period extending over 35 yr., been through about every stage of the power problem. Beginning with a small return tubular boiler using shavings and saw dust, which could be had for the switching charges on the cars, for fuel and 75-hp. slide valve engines, the plant progressed to one having a larger boiler and engine, still using waste fuel; then two 72-in. by 18-ft. h.r.t. boilers and an 18 by 48-in. Corliss engine were added.

SUPPLEMENTARY CONDITIONS INCREASE POWER COST

At this point some new buildings were put up. They were located west of the original group and across the street. The old Corliss had reached its limit so far as load was concerned and without putting up a right angle rope drive and buying a larger engine and one more boiler, it was found to be impossible to run the new part from the old engine room so it was decided to install motors and buy current from the utility company. Three-wire, 3-phase, induction motors using 220 v. were installed. The voltage on the incoming line was 2300, so a 3-wire, 3-phase, 100-kw., 2300 to 220-v. transformer, with switching equipment, was bought and installed. On November 1, 1906, the first contract for the purchase of power was made for a period of 10 yr. This was for 75 kw. at the switchboard, service to be as nearly constant as possible. The rate was $2 per hp. per mo. but the load factor, power factor, maximum demand and a few more little odds and ends, when all figured up, appeared as follows at the bottom of the bill: Number kw-hr. ÷ 0.746 = hp-hr. at $0.011 = amount of bill.

Up to this time and until 1909, our company ran an excelsior mill in connection with its other business. This mill was located across a railroad track, north of the main factory. Power was transmitted by a rope drive located over the top of the buildings. The center to center shaft distance was 250 ft. In that year, a new four-story building was constructed between the engine room and excelsior mill and an 85-hp. 3-wire, 3-phase, 2300-v. motor was installed in the excelsior mill to furnish it with power.

OVERLOADING MOTOR CAUSES TROUBLE

One great mistake was made in picking out the size of motor. The indicated horsepower of this load when all machinery was running was found to be 185 but the motor was bought over the plant engineer's protest and after installation would burn out periodically. From 1909 to 1922, this continued but the purchasers of the motor could not understand why, as the salesman had told them it would stand a 50 per cent overload indefinitely and a 75 per cent overload for 2 hr. In 1911, for various reasons, this excelsior mill was leased for a period of 10 yr. to another company engaged in that business, whose power was to be purchased of our concern. This leasing company ran the original motor 30 days and then threw it out and installed one of the same type but of 200 hp.

PURCHASED POWER AND MOTOR DRIVES

From 1909 to 1913, business expanded and more machinery and motors were installed, some of the latter taking part of the load off the engine until the average connected load was only 60 hp. Power and heating costs were climbing, so an efficiency engineer was brought in to see what could be done to reduce them. On his advice, the engine was shut down, everything run by motors and the boilers used only for heating and for furnishing steam for process work. The engineer's investigations brought out the following facts: Coal used in 1913 for heat and power, 1602 t., costing $4188.48. This was divided as follows: coal to run engine 609 t.; heating, nights, Sundays and holidays, 993 t.; Cost of purchased power was $4400.00, making a total cost of $4188.48 + $440.00 = $8588.48.

During the years 1914 to 1917 inclusive, boilers were used only for heating and steam was bought from our own boilers, if you wish to express it that way. In 1917, the government sent out questionnaires to power plants and I was delegated to assemble the data requested.

For the period under consideration, it developed that during this time, while the boilers were used for heating only, we had burned 1200 t. of coal per year. So the company decided to install a new plant and generate its own power during the heating months. For the year 1917 all power was purchased and the boilers used for heating purposes only, with the following results:

Coal used for heat only, 1061 t. at $5.40	$5731.31
Power purchased, 258,774 kw-hr.	3673.76
Total cost of power and heat	$9405.07

NEW POWER PLANT INSTALLED

The new power plant was started up January 1. 1918 and it ran 6½ mo. that year with the following results:

Power generated 6½ mo., 143,305 kw-hr.	
Total coal burned, 1080 t. and 450 lb. at $6.40	$6920.98
Power purchased, 5½ mo., 119,520 kw-hr.	1713.76
Total cost	$8634.74

Total power used, bought and generated 262,825 kw. This left a balance of $770.33 to our credit with coal at a cost of $1.00 per t. higher than before. All firing was by hand and the fuel was Hocking Valley and Youghiogheny screenings.

STOKERS INCREASE PLANT CAPACITY

During the summer season of 1918, one underfeed stoker was purchased for installation under the No. 1 boiler. Both boilers installed are 72 by 18 in. and of horizontal return tubular type. One boiler could not

carry the load alone, so, during the following year, a second-hand underfeed stoker was purchased and installed under the No. 2 boiler. The plant has been operated intermittently since that time and we have been running our own plant during the heating season and buying power during non-heating months; the excelsior mill taking care of the minimum power charge.

Mistake Results in High Demand Charge

When we shut down our plant in the spring, we paid for the power actually used, since, being under one contract, no attention was paid to the maximum amount used, until November 1, 1924. The original contract for electric power expired November 1, 1916 but, through oversight and a little clause at the bottom of the original contract, it was automatically renewed. Through a mistake made one day during the writer's absence, the load from the utility company's line was not switched to our generator for 2 hr.; the result was that the highest maximum demand in the history of the place was set up.

Shortly afterwards the manager of the excelsior factory, feeling that he was paying too much for power, complained to the utility company but received no satisfaction from them as they had no contract with him. The final result was that we had to accept a charge of $1200 ($100 per mo.) for the year 1925.

To remove the possibility of setting up another peak demand, we ran our plant through the entire year, using the utility company's service only a little at nights, when the excelsior mill was shut down, as the contract was for 24 hr. and it was impossible to set a maximum demand when the excelsior mill was not running.

Summary for the year 1925 was as follows:

Total coal bought, 1351 t. at $6.20	$8376.20
Coal for power, 732 t. at $6.20	4538.40
Coal for heat (engine not operating), 619 t. at $6.20	3837.80

Power generated 309,885, kw-hr. ÷ 0.746 = 415,395 hp-hr.

Coal per kw-hr. as generated, 4.7 lb.
Coal per hp-hr., 3.5 lb.
Cost per kw-hr., 1.46 cents.
Cost per hp-hr., 1.09 cents.

Attempt Made to Raise Electric Rates

In October, 1925, the utility company notified us that the old contract would not be renewed, as the rate was too low. The matter was then thoroughly investigated with the following results: Our engine runs regularly from 7 a. m. to 5 p. m., five days a week and from 7 a. m. to 12:30 p. m. on Saturdays. All other time is "overtime" and for such time our company paid $700 during the year under the old rate. Under the new rate, for the same amount and kind of power, the cost would have been $1700. This meant a jump of nearly 2½ times the former cost so the utility company's service was discontinued. At the present time, if a department cannot get its work out with the regular number of employes during the standard working hours, more help is added. This makes it better for the power house also, as it evens the load.

It will be noticed that no charge for attendance has been made when figuring the cost of producing power, as the labor cost is about the same whether power is bought or generated. In fact, the number of men employed in the power house has actually been reduced from four, when boilers were used for heating only, to two men working 12 hr. a day and another man working 2½ hr. daily to handle the coal.

Removal of Ash in Molten Slag Form

REMOVAL of ash from powdered-coal furnaces is frequently a source of difficulty because of its tendency to melt in the flame and accumulate in solid masses in the ash pit. Two large power plants which burn coal having easily fusible ash have, within the past two years, made trials of the removal of ash as molten slag. This consists in the installation of a hearth in the bottom of the furnace where the ash collects, melts and is tapped off at intervals.

Ability to predict whether this method can be successfully used in a furnace of a given construction when burning a given coal will depend on the ability to predict whether the ash deposited in the furnace will be sufficiently fluid at the temperature which will obtain in the slag bed. Comparatively little is known of the relation between the fluidity of the deposited ash and of the ash of the original coal. The Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce, is conducting an investigation of the subject in coöperation with a firm of designing and construction engineers. Three coals having fluid temperatures for the average ash of about 2400, 2600, and 2800 were burned. Some of the preliminary findings are as follows:

Selective separation occurred which increased the percentage of fluxes, iron and lime, in the slag compared with that in the ash of the coal. The per cent increase was greater as the percentage of fluxes in the original ash was lower.

Softening temperatures of the slags were lower than those of the original ash, but the fluid temperatures were not changed to as great an amount; the lowering of the fusion temperatures increased as the fusion temperatures of the original ash were higher.

Percentage of the total ash fired which passed to the stack increased with the fluid temperature of the original ash.

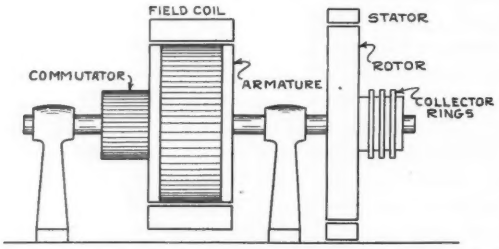
Percentage of the total ash fired which passed to the stack was about one third less with a boiler having a slagging bottom than it was with a similar boiler with a dry bottom when burning the same coal.

Slag from the molten bed would be expected to contain little combustible; as high as 8 per cent combustible was found in some samples.

Temperature of the gases entering the boiler tubes was 300 to 400 deg. F. higher at similar loads and excess air in the furnace with the slagging bottom than in a similar furnace with a dry bottom and water-tube slag screen; this was due to the smaller area of heat-absorbing surface, larger area of high-temperature surface and smaller volume of the slagging bottom furnace.

Building Up a Motor-Generator Set

IT OFTEN HAPPENS that a plant, in changing its power from direct current to alternating current, finds that, to change all the motors at one time will be uneconomical, due to the need of variable speed motors. So it was in a plant of which I was formerly in charge,



ASSEMBLING OF MOTOR-GENERATOR SET FROM SPARE PARTS SAVES $2000

where we had motors on the freight elevators, motors requiring a variable speed and motors not used a sufficient amount of time to require a large amount of current.

For these purposes, the writer constructed two simple motor-generator sets as shown in the illustration. These were made up of units we had on hand, without using a flexible coupling and by using only two bearings. By the use of this type of set, a smaller foundation and a smaller amount of floor space than usual was required. The power company, as well as one of the largest manufacturers of electrical apparatus, claimed that this type of motor-generator would never be satisfactory; yet these two motor-generators have been in use for 18 mo., giving perfect satisfaction.

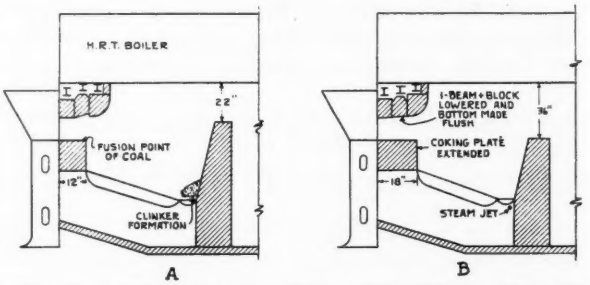
It so happened that we had a 125-hp. and a 100-hp. direct-current motor left, after making our change to alternating current, so we changed these motors into generators by pressing the rotor of a synchronous motor on the shaft of the direct-current motor where the pulley formerly had been. This improved our power factor, besides being economical to build and install as well as to operate.

The claim made by the power company was that these motor-generators would never be satisfactory on account of the two different magnetic pulls. My claim, on the other hand, was that, if the armature of the direct-current generator was centralized as should be also the case with the rotor of the alternating-current motor, then there would not be as heavy stress on the shaft as there had been when the new direct-current generator, changed from a motor, was used as a motor with a pulley on this shaft. The pull would all be in one direction, whereas with the alternating-current motor taking the place of the pulley, the pull would be equalized due to the magnetic pull. A saving of $2000 was made by using the motors we had on hand instead of buying complete new motor-generator sets. The motor-generator sets that were rebuilt have now been operating with entire satisfaction for over two years.

Kansas City, Kan. J. F. STALEY.

Changes in Furnace Construction and Fuel Overcome Troubles

ABOUT A YEAR AGO, we discarded two of our old stokers and substituted two of semi-automatic type but experienced trouble directly after their installation.



USE OF LOW VOLATILE COAL AND STEAM JET AND CHANGE IN FURNACE CONSTRUCTION SOLVE OPERATION TROUBLES

At first, our principal trouble was the loss of the end blocks of the ignition arch sections which broke out in less than a week's time. At the time, we were inclined to think that the loss of the brickwork was due partly to high sulphur content in the coal. The stokers would not feed the coal due to its fusing at the lip of the coking plate.

In order to make these stokers feed properly, we tried a number of different types but none worked satisfactorily. The ignition arch was then reconstructed by shortening the middle block, squaring off the lower surface and lowering the steel supporting beam 2 in., to bring this surface even with the other members of the arch. The coking plate was extended from 12 to 18 in. and the bridge wall lowered 14 in.

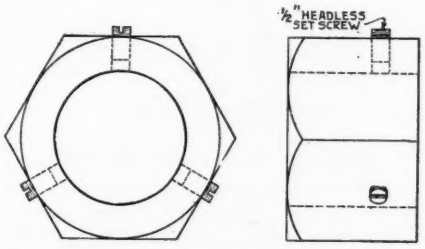
Since making these changes, we have had no further loss of arches but our trouble from coal fusion at the lip of the coking arch increased to such an extent that it was finally decided to change the kind of coal used. A trial of a couple of carloads of low volatile coal seemed to bear out our conclusion as to the effect of high volatile content on clinkering, hence low volatile coal was adopted.

We also had trouble at the bridgewall due to clinker formation which was so great that the dump plate failed to function. To overcome this, a steam pipe was installed under and across the rear of the grate. Holes 1/16 in. in diameter and spaced 2 in. apart were drilled in this pipe and a small quantity of steam was allowed to pass through these holes at all times. All trouble at this point was overcome in this way. Since the above changes were made, the two boilers have been in continuous operation for over a month and are working perfectly satisfactorily.

Mechanicsville, N. Y. R. F. LEACH.

Pump Shaft Sleeves Removed by Use of Nut

CENTRIFUGAL PUMP impellers are often held in place by brass shaft sleeves which are threaded and screwed on the shaft. To change impellers in such a pump will sometimes look like a hopeless job but it will not be so,



DEVICE MADE OF NUT REMOVES TIGHT BUSHINGS FROM SHAFT WITHOUT INJURY

if it is properly handled. Usually, the worst part of the job is to remove the sleeves. Of course, if the sleeves are badly worn or cut, so that they must be replaced, they may be removed with hammer and chisel, pipe wrench and acetylene torch. But when the sleeves are to be kept in good condition and put back, they cannot be marred.

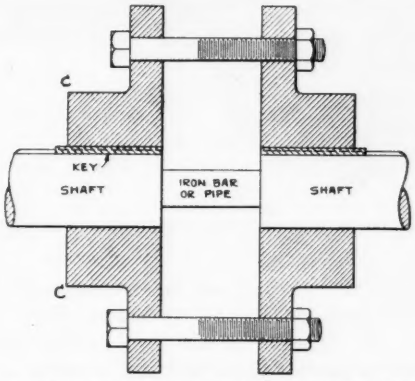
When this is the case, a simple way to remove the sleeve is to twist it. At one end of the sleeve you may find one, two or three holes, apparently intended for a spanner wrench. If there are no holes, they may be drilled in the sleeve for this purpose though, of course, no spanner wrench on earth would turn an old sleeve when it is well rusted on. The rusted tube may buckle but it will not twist.

Under such a circumstance, hunt up an old hexagon nut of such size that the threads may be bored or reamed out so that the bored nut will just slip over the sleeve to be removed. For instance, if your sleeve is 2 in. dia., get a nut for a 2-in. bolt. Then to engage the three or more spanner wrench holes, you will have to put set screws in three or more sides of the nut you have bored out. If the sleeve is thin or appears to be rusted on, it is better to use all six sides of the nut, i.e., six set screws. With this special nut carefully set in place, you may use any kind of wrench and remove the sleeve without damage.

Springfield, Mo. R. E. THOMPSON.

Shaft Coupling Removal

MODERN TYPES OF SHAFT couplings are easy to remove at any time, but when it becomes necessary to remove one of the old solid, two-piece, flange type of fair size, the proposition is different, especially if the coupling has been forced on to the shaft and perhaps held in place by tightly driven headless keys. In the



SHAFT IS FORCED OUT OF FLANGE WHEN BOLTS ARE TIGHTENED

past, some erectors appear to have had the belief that such flange couplings would never have to be removed. Quite often, pounding with a heavy hammer, even while heating the flange, fails to start a coupling and ultimately it is split off.

Successful removal of a flange coupling from an old line shaft may be accomplished in the manner illustrated. The bolts are removed from the coupling and the flanges separated a couple of inches so as to permit interposing a piece of iron rod or pipe, which is smaller in diameter than the diameter of the shaft. After placing this as shown, long bolts, which should have long threads, are entered and tightened up as much as possible without stripping the threads. Now, using a fairly heavy hammer, strike the flanges around the ends at C, C and at the same time have an assistant apply a little more pressure on the nuts.

Often both flanges will let go at the same time. Should only one flange loosen, however, remove the piece of iron bar or pipe and place a stiff piece of iron plate over the hole in the loosened flange, then separate the flanges a little more so as to set one end of the iron bar on the iron plate and the other end against the shaft end at the unloosened side. Now retighten the bolts and repeat the hammering at the tight flange end. The flame of a blow torch applied to the flange end as soon as you start the hammering may help but, if the flame is held there until the shaft also heats, it will not help.

Toronto, Canada. JAMES E. NOBLE.

RADIATION, conduction and friction of engines are always losses except in cold weather when they may furnish sufficient heat to maintain a comfortable temperature in the engine room.

Hose Racks From Old Carbide Cans

For small air, water and steam hose, an excellent rack or holder can be quickly made from one or two halves of empty carbide cans as shown. A light single or cross block fitting the inside of the can is fastened to the wall and the can tacked to it. A hose of considerable length can be quickly wrapped on or unwound

CORRUGATIONS IN CARBIDE CANS HELP TO KEEP HOSE ON IMPROVISED HOSE RACK

from it and the corrugations in the can keep the hose on and in place. It is easier to handle than any kind of a reel with lengths of this type of hose which are often kept connected for sprinkling, washing, or blow-off purposes.

Missouri Valley, Iowa. Frank W. Bentley, Jr.

Home-Made Metallic Packing Serves Well

One of the experts in the service of the Ontario Government used a home-made metallic packing during my connection with that service, which was easy to make, inexpensive and gave as good service as some of the costly packings. It was used on valve spindles, on steam engines and for nonsuperheated steam work generally, also for ammonia, air, gas and hot water packing. The making of this metallic packing is so easy I thought I would pass the process along.

All that is necessary to make it is a clean babbit melting pot, a pouring ladle, a piece of 1/16-in. iron mesh screen about 12 in. square and a pail full of clean cold water. To make about 8 lb. of the metallic packing, melt 6 lb. of lead, 1½ lb. of antimony, 6¼ oz. of Banca tin and ¼ oz. of bismuth in the pot. When melted, stir in a piece of rosin about half as big as a marble and skim off all dross. Now, hold the wire screen about 12 in. above the pail of water and, using the ladle, pour the well-mixed metal slowly through the screen, the metal will then be broken up when it reaches the bottom of the pail, into fine parts of nearly even size.

When all the metal wanted is poured, drain off the water and place the fine metal in some warm place to dry. While the 8 lb. of metal are warm and dry, stir in it about a pound of melted paraffin wax and 11 oz. of powdered graphite. The mixture can be kept ready for use for years in a tight covered can.

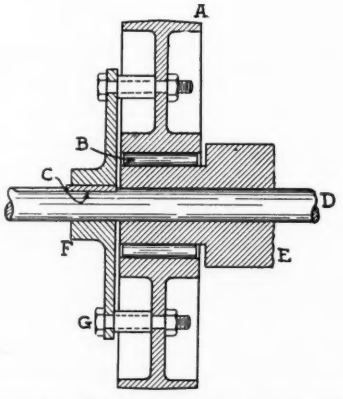
To use the packing, clean out the packing box and insert one ring of ordinary fibrous soft packing, then fill the box with the metal packing, driving it up tight with a piece of hard wood and leaving space to take another ring of the soft packing. The packing will take about a 10-hr. run, with several tightenings of the packing box gland to bed up, after which it will be good for a very long time.

Toronto, Canada. James Ellethorn.

Mounting of Pulley on Housing Eliminates Shaft Deflection

An excellent way to eliminate every bit of belt pull from shaft bearings is shown in the sketch herewith. Shaft deflection due to belt pull is therefore eliminated also. This method requires small space and, instead of requiring an additional bearing as is frequently the case, only one—a roller bearing which consumes less power than ordinary plain bearings—suffices.

By turning down the housing, E, of the motor, as shown in the sketch, or by casting such a housing and attaching it to the motor, all the belt pull falls directly upon the shaft housing. The pulley should be mounted on this housing and equipped with roller bearings, B, between the pulley and hub. The flexible coupling, F, shown at the left is keyed to the shaft, D, and is connected to the pulley, A, by means of bolts, G, or by other methods familiar to those who use flexible couplings.



PULLEY DRIVE STIFFENED BY ATTACHMENT TO HOUSING HUB

By applying this method, there can be no binding or deflection in the shaft and friction is reduced. No more space is used by this method than when the pulley is placed, as it often is, on the end of the shaft, thereby giving undesired overhang. With this method, the force on the shaft produces a purely twisting action which is an ideal condition. The only bending is that caused by the weight of the shaft itself plus whatever the shaft supports.

If desired, ball bearings may be used in place of the roller bearings shown. Or, if roller or ball bearings are considered too expensive, a plain bearing of the anti-friction type could be employed. In any event, this arrangement is more satisfactory than an overhanging pulley. Its first cost may be greater but, in many instances, first cost is of much less importance than reduction of space and power requirements.

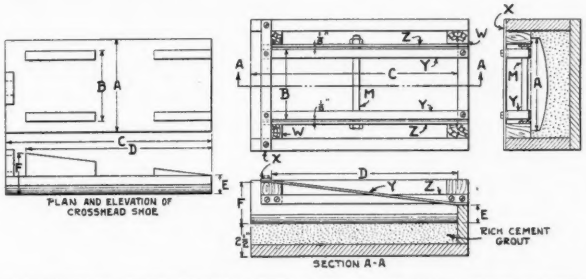
Newark, N. J. W. F. Schaphorst.

Questions and Answers

Mold for Babbiting Crosshead Shoes

How do you babbit the top and bottom shoes of a horizontal steam engine crosshead? W. F. W.

Babbiting crosshead shoes in the guides is not always a successful operation. Unless the guide is quite warm, it will sweat when the hot metal is poured in, causing blowholes on the face of the babbit. Unless considerable care is taken to provide air vents at the highest points, the air is likely to be trapped in a corner, thereby shutting off the babbit and leaving a large corner of the shoe unfilled. Great care is also necessary in sealing around the sides and ends of the shoe.



BABBITING CROSSHEAD SHOES IN A MOLD OVERCOMES DIFFICULTY WITH AIR HOLES

If a mold as illustrated is used, all of the difficulties mentioned will be overcome and the mold may be kept for permanent use. In preparing this mold, the bottom and sides of the box are nailed together first, then the front end is nailed in. Care should be taken to see that the end reaches only a short distance above the bottom and not to the top of the sides. The rear end is left open.

Cross strips X-X, Y-Y and Z-Z are made of ¼ by 1-in. iron. The strip X is fastened to the sides of the box by wood screws. The two strips Y, are held by wood screws in the end of the box, and by ¼-in. countersunk bolts which fasten them to the under side of X-X. Four wooden blocks, W, are nailed to the sides of the box near the ends and to these blocks the strips, Z, are fastened by wood screws. The strips, Y, form a bearing for the top faces of the lugs on the back of the shoe and the strips Z form a guide for the side faces of the lugs.

To prepare the mold, invert the box and slip the shoe in as if it were being placed in the crosshead next to the upper guide. Now tighten the nut on the bolt M, thus clamping the strips Z against the side of the lugs and holding the shoe in position. The box is now reversed and the rear end temporarily closed. A rich cement grout is then poured in until it reaches a level slightly below the top edge of the shoe. When the grout has become set, the shoe is removed and the mold is ready for use.

A new shoe should preferably be used in forming the mold, to insure a correct bearing and the proper thickness of babbit. If a worn shoe is used, it should be lined away from the strips Y to allow for the wear. The principal dimensions are lettered to correspond with those of the shoe as shown in the lower drawing.

This mold can be quickly warmed when it is to be used, is easily sealed and, as it is placed on end and poured from the top where there is a large open space, there is no tendency to trap the air.

Wetness of Live and Exhaust Steam

Your answer to the following question will be appreciated: Does exhaust steam at 5 lb. pressure have more water or saturation in it than live steam of the same pressure? J. B.

A. The term "saturation" when applied to steam, implies absence rather than presence of water. By "saturated steam" is meant fluid in which there is nothing but steam, hence no water.

Usually the exhaust steam will have more water or moisture in it than live steam of the same pressure. Starting with high pressure steam which is perfectly dry and has no moisture in it, during the expansion through the engine some of this is condensed and its heat of evaporation is converted into work. This condensation will be in the exhaust steam.

The amount of such condensation will depend on the amount of the expansion, that is, the pressure range between the initial pressure and the exhaust pressure. There will also be some condensation due to heat absorption by the cylinder walls and piston.

On the other hand, live steam at 5 lb. pressure, would usually be secured by passing through a reducing valve from a higher pressure and in this very process of passing through the reducing valve or throttling, some of the moisture, which might be in the live steam, will be evaporated.

Weight Change on Shaft Governor Changes Engine Speed

To increase the speed of an engine governed by means of a shaft governor, would you move the weight toward or away from the pivot? A. J. F.

A. In an ordinary shaft governor, if the weight is moved toward the pivot or in a Rites governor, if weight is removed from the long arm, the engine will speed up.

New orders for 1025 steel boilers were placed in February, as reported to the Department of Commerce by 81 manufacturers, comprising most of the leading firms of the industry, as compared with 1075 boilers in January and 1171 in February, 1928.

Editorial Comment

Engineering Education Takes a Long Step Forward

During the past few years, educators and administrators in all our colleges have been giving much thought to the various criticisms that have been directed at our existing educational systems. The prevailing American idea, that everybody is entitled to all the education there is, has created problems in our schools and colleges that never were known to educators before. (What the great mass of Americans want is training, not education—but that is another story.) As might have been expected, the methods that had to be developed to solve these problems were not flawless. One of the principal disadvantages of these methods was that no provision was made for the undergraduate student of the highest ability, who has often been forced to hold back in order to accommodate himself to the routine prescribed for the great mass of students of average ability, to whom the entire machine had to be geared down.

Educators have often thought that this superior student might work much better under the European system of tutoring, reading and "being smoked at," as one Oxford graduate has put it, with comprehensive examinations designed to test his power of solving problems and meeting new situations, as well as of his grasp of details and facts. Certain of the liberal arts colleges have been considering such schemes but have not reported much progress.

It remains for two of the leading engineering colleges to announce that for some time the process of "reading for honors" has been incorporated in their courses in electrical engineering. At some time during the sophomore year of the undergraduate course, a small group of the highest-grade students is urged to follow this procedure. These men are put entirely on their own responsibility, are not required to attend regular classes except when they feel it advisable, are given the closest supervision by examination, faculty advice and other methods and are allowed to go ahead just as fast as their abilities will permit.

In a word, they are taught to teach themselves—the highest form of teaching—they are allowed to specialize in the things that interest them most and they also secure a knowledge of the relation of their specialties to all other knowledge and a broadness and depth of culture that are so often lacking in the average undergraduate. The results reported have been most satisfactory. Details of the process cannot be given here but those interested can find them in a recent issue of the Journal of Engineering Education.

These two engineering colleges seem to have actually accomplished what many other institutions have only been talking about. It is significant that definite and public recognition has at last been given to the fact that a standardized educational system does not fit everyone and that students of higher ability than the average actually exist. It should be a source of pride to every member of the engineering profession that such practical recognition of a vital principle has been given by engineering colleges.

Training Power Plant Operators

Lack of dependable and capable help seems to be as universal a complaint in the power plant field as in other industries and walks of life. Taken as a whole, the turnover is probably less than in other fields but chief engineers and superintendents seem to feel that the quality of this labor is decreasing and they find it increasingly hard to hold the better men.

The situation is more acute in the industrial field than in central stations although the latter, especially the smaller utilities, are not entirely free from the complaint. In spite of the increasing difficulties, however, comparatively few utilities and still fewer industries have felt the need of or have had the ability to organize classes or schools to build up their personnel.

Manufacturers in all sections of the country have, in recent years, suffered from the breakdown of the apprenticeship system and finally faced a situation when the lack of trained men forced action. Not only individually but in entire communities, manufacturers found it necessary to get together and put a modified apprenticeship system into operation.

In the power plant field, some of the larger organizations have training courses where technical graduates are trained for from six months to two years, eventually fitting into the organization at the work for which they appear to be best equipped. For the operating departments, comparatively little has been done along this line. Many of the companies prefer to build up their operating personnel from the labor corps.

From the standpoint of stability, this system has advantages. Such men have no preconceived ideas or opinions, so that they fit into and pick up the methods and organization of the chief engineer or superintendent without argument. Furthermore, it offers steady, reliable employment with a social and economic position above that which they formerly occupied and thus tends to reduce the turnover. With growing organizations, however, this plan has disadvantages in that few such men are capable of advancing beyond watch engineer and when higher positions are to be filled, it is necessary to go outside of the organization.

Other companies have tried to use a higher grade of labor, training them in both the boiler room and turbine room so that capable men could be advanced indefinitely and the organization, even though expanding rapidly, built up entirely from within.

Need for specific training programs for the operating department is becoming more acute as the industry expands and, although a uniform training plan is hardly

practical in the present transition stage, numerous companies are giving serious thought to the matter. In the course of time, training of the operating department personnel should become as well established as the apprenticeship program in manufacturing industries.

Duty Performed as an Art Is Its Own Reward

Once again, after a lapse of 11 yr., the war department at Washington has discovered a new hero. There is nothing new in the delay of earned recognition, for such delay is commonplace; there is nothing unusual in the fact that the hero's wife had not even heard of the incident of heroism that brought him a distinguished service cross, for often those who were in the thickest of the fight are least disposed to discuss it; nor was it of particular note that John Hogan was only a buck private when he captured a machine gun nest single handed, for much of the valor displayed during the war was exhibited by the men in the ranks.

Significance centers on Hogan's remark, "It isn't getting the cross itself that counts, it's the knowledge that something I did was good enough to merit it." This emphasis upon the worthwhileness of the deed and willing response to a call of duty rather than upon the reward is noteworthy. It should be emblazoned upon the walls of every plant, factory or office where men are employed.

To desire a direct and immediate reward for a duty done is instinctive; to regard as paramount the duty which is to be done, with no thought of the reward, is the mark of a superior standard.

Most of us place too much emphasis upon the receipt of credit for things accomplished and, in so doing, we lose much of the force of accomplishment. Credit, like many otherwise good accessions, comes best when it is unsought. If we can consider our work, however humble, as an art, we shall inevitably raise the standard of performance of that work and incidentally increase our pleasure in its accomplishment.

Off Duty

"Ah, dearest," sighed the amorous undergraduate, "your eyes are the blue of a mountain lake on a summer evening; they ——"

"Be yourself, boy friend, be yourself!" interrupted the snappy co-ed specializing in physics. "You know that's all hooey. Why, on Prof. Hardy's new spectrophotometer in the physics lab, the other day, the color of my eyes tested 440 millimicrons and, you know, that's certainly not the blue of a mountain lake."

So it goes. Every day some scientist with some newfangled device takes the romance out of life. At the Westinghouse laboratories, not long ago, an electrical instrument recorded the fluttering heat beats of a pair of lovers as they kissed each other, presumably to measure whether or not their love was up to standard. Romance, instead of being expressed in beautiful lies is recorded in ragged curves on rectangular coördinates by a machine with a vacuum tube for a soul.

Machines for everything. Take this machine of Professor Hardy referred to above—it does everything but blush. Not only does it measure color accurately, but it makes a record by which it is possible to match that particular shade or tint at any time, thus eliminating all possibility of a standard color fading.

To operate it, it is necessary only to place a sample of the desired color before a window in the instrument, turn on the current, wait a moment, and then remove the paper on which a color value curve has been recorded. The operator then compares that curve with those of the samples already on file, or makes a curve of that color which seems to be like the one in question. If the curves are alike, so are the colors.

The apparatus consists, essentially, of a means for breaking up the light reflected from a sample, measuring the intensity of each portion of the spectrum as compared with a standard, and recording the result as a continuous wave on a chart. The sample is compared with magnesium carbonate, the whitest substance known. Both sample and standard are illuminated by a special ribbon filament incandescent lamp. Shutters actuated by motors, admit alternate beams from the sample and standard to the slit of a spectrograph. Another movable slit is automatically adjusted so that each portion of the spectrum or color band of light is admitted in turn to a photoelectric cell. As the light of single wave length is reflected alternately from the sample and standard, and as the intensities differ, a pulsating current is set up in the photoelectric tube. This current is passed through amplifiers, increasing the power some ten billion times and is then fed to a motor which adjusts the shutter between the light source and the standard to that position where the current pulsation ceases. The opening of the shutter, then is a measure of the intensity of a particular spectrum line in the specimen color. The machine thus, automatically compares minute portions of the specimen's spectrum with the standard and records the analysis on a revolving drum.

In this day of "color," when everything from coffee strainers and mop handles to soft drinks and de luxe trains, reeks with all the shades in the spectrum, a machine of this kind should prove of great value. The application referred to above is only one which comes to mind. In many industries, a slight variation in the color of the product is of great moment. Lubricating oils may be graded for certain characteristics on the basis of color, and differences in shade, often too small to be noticeable, result in hot argument. This machine will settle such arguments once and for always, since its findings are not biased by prejudice.

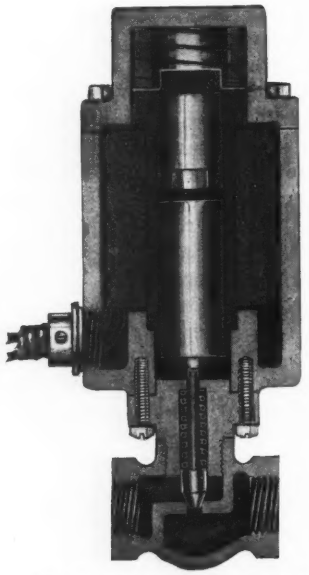
An important use for the recording spectrophotometer is the recording and cataloging of the curves of different dyes, so that new colors with predetermined characteristics can be obtained at any time by the proper mixture of standard dyes already at hand.

This instrument was developed by Professor Arthur C. Hardy of the Department of Physics at Massachusetts Institute of Technology and of the staff of the research laboratory of the General Electric Co. Whether or not he has used it on co-ed's eyes as suggested above, we do not know; we suspect not. If he has any such intentions, however, we would advise him to be careful for we have an idea that if his machine were pointed at some of the bewitching orbs we have seen, the recording pen might twist itself into a knot or burn up.

Power Plant Engineering Developments and News

Packless Type Solenoid Valves

FOR USE on all types of automatic control systems such as those handling gas, oil, water or air, the solenoid operated valve shown in the accompanying illustration has recently been developed. This valve is



SECTION THROUGH PACKLESS TYPE SOLENOID VALVE

governed by a thermostat, pressure regulator, float switch or other device of this nature. Its principal characteristic is that it is packless.

As can be seen in the illustration the solenoid movement is built so that a rust proof steel plunger, directly connected to the stem of the valve, is allowed to slide in an air-tight housing of a special composition. This housing is sealed by a steel cap forced down on it with considerable pressure by a high tension spring. Under operating conditions when the temperature of the solenoid rises, an expansion of the cast-iron housing occurs and the spring, which exerts constant pressure on the top of the plunger housing, allows this expansion to take place in order to keep the plunger chamber leak-proof under these conditions.

The fluid to be controlled is allowed to flow into the plunger chamber and it is stated that this will not cause any injury to any part of the apparatus since the plunger housing is entirely tight. Operating parts of the solenoid are rust-proof and the valve stem slides through a brass bushing to prevent sticking.

The magnet is designed so that it will not overheat under continued service in the open position and so that failure of the current causes the valve to close. The valve closes with the flow to assure tight seating. To actuate the solenoid, remote control can be used or automatic control from various types of instruments. In the latter case, relays must be interposed between the controlling device and the solenoid valve. These packless type solenoid valves are manufactured by Electric Valve Mfg. Co., New York City, and are being placed on the market by Charles Engelhard, Inc., Chestnut St. and N. J. R. R. Ave., Newark, N. J. They can be supplied in various types such as the needle type, disc type with renewable discs for any fluid, semi-balanced type and piston type and in sizes ranging from ¼ in. to 3 in.

Current Transformers with Hipernik Cores

WESTINGHOUSE ELECTRIC and Manufacturing Co. announces a new type current transformer that is suitable for all applications with secondary burdens up to 50 volt-amperes, at any power factor, at

CURRENT TRANSFORMER WITH HIPERNIK CORES

frequencies between 25 and 133 cycles, and on lines up to and including 6900 v.

Extreme accuracy is obtained in the new type transformer by using hipernik instead of silicon steel for the core. Hipernik, which is an alloy made of pure nickel and electrolytic iron, specially treated, is non-aging and has three times the permeability of regular silicon steel and but one-half the losses. The primary coil of the new transformer is wound with a sufficient number of ampere-turns to assure good performance and like performance of all ratios. The coil is almost circular, thus

assuring strong mechanical construction. The coils of low-current rating are made of light copper strap but up to 100 amp. are provided with the same terminals which are stiff sturdy copper strap, ¼ by 1 in. Two bolt holes are supplied in the primary for installing two bolt terminal lugs. The secondary coil is circular and the leads are brought out to a terminal block. It is properly insulated from the primary coil to withstand a test of 20,000 v.

End frames are of sheet steel and are used to hold the laminations tightly together. They are provided with feet suitable for mounting the transformers on a flat surface, transverse or parallel pipe framework by means of standard sized U bolts.

A secondary terminal block is provided on which are fixed studs to which the secondary wiring of meters, instruments or relays may be connected. A cover is supplied for this block which protects the secondary connections, preventing tampering by unauthorized persons.

The NA transformer, as this new type is designated, is considerably lighter than similar ones with silicon steel cores and it will withstand, mechanically, short circuit currents up to 70 times normal primary rating. The time limit due to thermal capacity of this type of transformer is one-half second for this current.

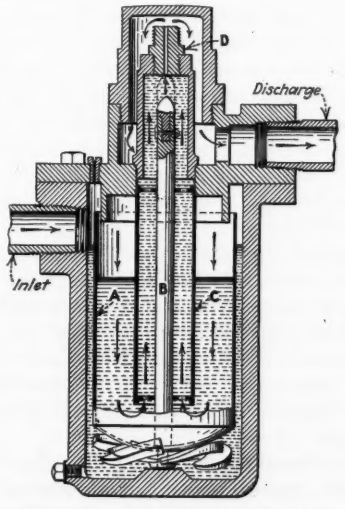
It is available in sizes ranging from 5 to 1200 primary amp.

Steam Trap has Self-Cleaning Valve

IN THE ACCOMPANYING illustration is shown a steam trap recently placed on the market, consisting essentially of body, bucket A, valve spindle B, guide sleeve C and valve seat D. Water enters as shown and rises in the trap body until it overflows into the bucket which floats and keeps the valve closed until enough water enters the bucket to overcome its buoyancy, causing it to sink and open the valve. Water from the bucket then discharges through sleeve C to the discharge pipe until sufficient water is discharged so that the buoyancy of the bucket will cause it to rise and close the valve.

To the bottom of the bucket is attached a small aluminum propeller, designed to rotate the bucket as it rises and falls, due to the action on the blades of the water in the trap body. This rotation, it is stated, cleans valve and seat and keeps the valve tight, since the valve is rotating as it closes; it also tends to eliminate wiredraw and seat cutting, as the valve will seat in a different position at every discharge of the trap. The seat is reversible; seat and valve are of chrome nickel.

Its manufacturer, H. O. Trerice Co., 1338 W. Lafayette Blvd., Detroit, Mich., states that the trap is equally suitable for removing condensation from air lines or discharging oil from separators. For steam lines, it is built for any pressure or superheat and is furnished in three sizes with capacities of about 2400, 7800 and 14,400 lb. per hr. respectively.



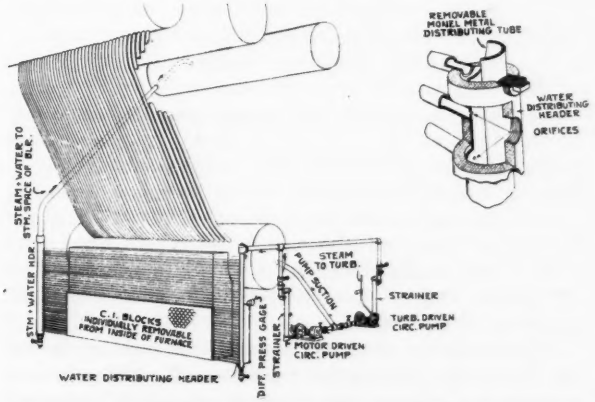
CROSS-SECTION OF TRERICE STEAM TRAP

Riley-La Mont Water Wall

AS AN ALTERNATIVE to natural boiler circulation and large diameter tubes, as used with most water wall constructions at the present time, the Riley-La Mont water wall, shown herewith, is based upon the use of forced circulation. The wall is constructed of small diameter flexible tubes in conjunction with small headers, to insure positive and proper distribution throughout the system.

Positive circulation is maintained in a single direction by means of a centrifugal pump of proper characteristics and by distributing orifices, designed to meter the proper quantity of water to each individual tube. Water enters the circulating pump by gravity from a drum of the boiler; its pressure is increased by the pump from 15 to 40 lb., depending upon the rate of heat absorption of the water wall. This water enters a header supplied with distributing orifices to meter the proper quantities of water supplied to each tube. Capacity of these orifices is such that the quantity of water forced into each tube is several times the quantity of water which will be evaporated under the condition of maximum heat absorption.

This quantity of water, however, is insufficient to fill the tube. As heat is absorbed in the tube, part of



RILEY-LA MONT WATER WALL APPLIED TO BRIDGE WALL OF BOILER. SECTION SHOWS WATER HEADER WITH DISTRIBUTING ORIFICES

the water is turned into steam, the volume of which compared to the quantity of water, is great. Steam thus produced cannot find its way out of the orifice end of the tube so that it must leave the other end of the tube, entering the header connected into the steam space of the boiler. The tubes are long compared to their cross-sectional area, so that the steam generated produces exceedingly high velocities in the tubes. Steam from the header moving at great velocity carries with it the excess water which entered through the orifices. It is stated that with such positive circulation steam binding under these conditions is impossible. Further, with this construction the tubes may be installed vertically, horizontally or at any desired angle with the flow either up or down and the tubes can also be bent at any angle to avoid structural obstacles and furnace openings.

Many advantages are claimed for this system of water wall construction. It is designed to eliminate steam binding and tube failure caused by this binding. Due to the flexibility of the small tubes, it is stated expansion and contraction will not cause leaks at the water wall headers. Its adaptability is intended to permit its installation where it might be impossible to make use of the natural circulation type of water wall. This is particularly advantageous where it is desired to install water walls on existing boilers. The high velocity through the tubes, it is claimed, interferes with the formation of scale or other feedwater deposits and obviates the necessity of using refractory or cast-iron blocks to decrease the rate of heat absorption of the water.

Accompanying sketch shows this construction applied to the bridge wall of a bent tube boiler. The small sectional view shows the water header with the small distributing orifices. The Riley-La Mont water wall is being placed on the market by Riley Stoker Corp., Worcester, Mass.

Pioneer Dynamo to Light Ford's Historical Exhibit

New York Edison Co. has presented an old electrical unit, consisting of a steam engine and two generators, to Henry Ford. After years of faithful service, this veteran dynamo will go to Mr. Ford's Museum of American Industries at Dearborn, Mich., and will supply the light for that famous exhibit. This old unit, the first of its kind ever to be used in a central generating station, represents that early transition period in electrical practise which saw the introduction of tall "skyscraper" apparatus in order to conserve space.

This machine, which saw many years of service at the Duane Street Station in New York City, stood some 24-ft. above its foundation and weighed about 100 t. When dismantled and boxed for shipment, it occupied four freight cars. During a recent visit to the Duane St. Station, Mr. Ford said that he intended to use it to supply some of the lights in his museum in order that the visitors might see some of the pioneer electrical apparatus in operation.

When this old dynamo was first put into service at the Duane St. Station on December 15, 1891, it was considered almost the last word in up-to-date electrical apparatus. It had a three-cylinder engine capable of developing 625 hp., and two 200-kw. direct-current, multi-polar generators. Compared with the giant 160,000-kw. turbine-generators of today, however, it seems little more than a plaything.

A bronze tablet, bearing interesting technical and historical data regarding the unit, is now being cast. The inscription on this tablet is as follows:

"The First Marine Type Triple Expansion Direct Connected Generating Unit for Central Station Use. Van Vleck disconnective type engine, Joy valve gear. Cylinders 18, 27 and 40 in. in diameter; stroke 30 in.; rated horsepower 600; 120 r.p.m. First used December 15, 1891. Designed by John Van Vleck, chief engineer, the Edison Illuminating Co. of New York, assisted by David Joy and S. F. Prest. Built by Dickson Manufacturing Co. of Scranton, Pa., J. W. Sargent, chief engineer.

"Two 200-kw., 150-v., 1333-amp., direct-current generators, built by the Edison General Electric Co. The first multipolar units built for direct connection. Presented by the New York Edison Co."

A. S. M. E. Knoxville Meeting Well Attended

AT THE REGIONAL meeting of the A.S.M.E. held in Knoxville, Tennessee, March 21 to 23, approximately 200 registered to enjoy a well-arranged technical program and numerous inspection trips planned to give visitors a comprehensive idea of the industrial development of the East Tennessee District.

Following a short address of welcome by Mayor James A. Fowler, the first technical session was opened by the presentation of a paper dealing with "Some Factors of Furnace Design" by F. C. Stewart, assistant professor of Experimental Engineering at Georgia School of Technology.

Professor Stewart said, "A furnace must be designed to accommodate the fuel burning apparatus used—also the quality of fuel intended for use. The furnace must also be provided with means of admitting proper quantities of air at the most suitable locations so as to give maximum efficiency along with low maintenance costs. A shape and size of furnace should be selected that will give the necessary capacity for the use intended and that will make it possible to attain complete and smokeless combustion. The efficiency of a boiler furnace is dependent to a great extent upon how these requirements are treated in the design." Following this introduction, he discussed in detail various factors such as wall construction, refractories, cement, size, shape, volume and fuels.

This paper was followed by the "Design of the Gorgas Steam Plant of the Alabama Power Co." by John M. Gallalee, professor of Mechanical Engineering of the University of Alabama. After reviewing the demands which made this additional steam plant capacity advisable Professor Gallalee discussed the selection of the site, estimate of costs for 450,650 and 1400 lb. pressures and concluded that, for the assumed capacity factor and cost of coal at the site, 450 lb. pressure was most suitable.

"Use of Powdered Fuel in a Standby Station," by H. H. Bailey, superintendent of production of the Tennessee Electric Power Co., concluded the morning

session. In November, 1927, two 1451-hp. pulverized fuel boilers with water-cooled walls, superheaters and air preheaters were installed in the company's Nashville station. During certain periods, this plant floats on the line for voltage regulation and standby service, at other times is operated at moderate ratings 12 to 18 hr. a day and for a few months is operated at 24 hr. a day.

Pulverized coal has been highly satisfactory for this service. Western Kentucky and Central Tennessee coals with high ash and an appreciable amount of pyrites are used. A typical analysis shows 38.95 per cent volatile, 45.35 per cent fixed carbon and 15.70 per cent ash with a B.t.u. content of 12,195 on a dry basis. Coal of similar analysis with as high as 9 per cent surface moisture (about 13 per cent total) has been handled satisfactorily with a reduction in capacity of about 30 per cent.

Pulverizer Maintenance Expected to Be About 5 Cents Per Ton

Hammers originally had a life of only 500 t. but a new type gives promise of increasing this to about 2000 t. A recent check after 700 t. showed 70 per cent through 200 mesh and 97 per cent through 48 mesh. At first, pulverizer maintenance ran around 15 cents per ton. This was reduced to 7 cents per ton for the last six months of 1928 and it is expected that this will be lowered to 5 cents or about the same as equivalent charges for stokers.

In the afternoon session of the first day, two papers were given: "Training Junior Executives for the Printing Industry," by E. W. Palmer, President of the Kingsport Press, Kingsport, Tenn., and "Mechanical Methods and Advances Made in the Quarrying and Mining of Marble," by J. P. McCluskey, Superintendent of the Gray Knox Marble Co. of Knoxville, Tenn. This session was adjourned early for inspection trips to the quarries and marble mills of Knoxville and the recently completed Knoxville filtration plant and pumping station.

After a short entertainment in the evening, a third session was held for the presentation of three papers. "Combined Stresses in Thick-Walled Cylinders," by E. B. Norris, Dean of Engineering, Virginia Polytechnic Institute, Blacksburg, Va.; "The Domestic Fuel Problem as Modified by Low-Temperature Carbonization," by Geo. A. Orrok, Consulting Engineer of New York, and "Low-Temperature Carbonization of Southern Appalachian Coals," by Leo Holdredge of the University of Tennessee, Knoxville, Tenn. Both of these papers dealt primarily with domestic fuel.

Inspection Trips Well Attended

Two inspection trips were arranged for the morning of the second day, one to the American Zinc Co. mine and mill at Mascot and one to the Aluminum Co. plant at Alcoa. Those who remained attended the technical session and heard "Relation of Development of a City to That of a Surrounding Region," by James Arentsen, State Superintendent of Industrial Education, Knoxville, Tenn.; "Resources of Southern Appalachian Slopes," by J. K. Marquis, Superintendent of Water Works, Spartanburg, S. C., and S. B. Earle, Director of Engineering, Clemson Agricultural College, Clemson College, S. C., and "The Survey of the Tennessee River System by the Corps of Engineers, U. S. A.," by J. A. Switzer, Professor of Hydraulic and Sanitary Engineering, University of Tennessee, Knoxville, Tenn.

In the year 1926, the total installed capacity in the Tennessee River Basin was about 660,000 kw., a little less than half being in steam plants. With the entire system developed for navigation, water power and flood control and at 50 per cent load factor, there would be required 4,777,800 kw. of hydroelectric capacity and 1,077,000 kw. of steam capacity. Generation by steam would be less than 12 per cent of the whole.

In the early afternoon, after a drive through the city, the meeting was called to order in the Plant of the Fulton Sylphon Co. William S. Lyhne, of that company, outlined "New Departures in the Manufacture of Thin Wall Tubing," with particular reference to new equipment they have developed for drawing practically any metal to wall thickness as low as 0.004 in. Present equipment will handle sizes ranging from 1 to 6 in. in diameter and 10 ft. long.

After an inspection of this plant, the meeting was adjourned to attend the celebration of the Association of Collegiate Engineers and to inspect the laboratories of the University of Tennessee.

The banquet held in the University of Tennessee Cafeteria was presided over by George Abernathy. A short address of welcome was made by Dr. H. A. Morgan, president of the university, and the principal addresses were given by Ralph E. Flanders, of Jones & Lampson Machine Co., Springfield, Vt., manager of the A.S.M.E., and L. W. Wallace, executive secretary of the American Engineering Council, Washington, D. C.

American Welding Society Meets April 24-26

Tentative program has been announced for the annual meeting of the American Welding Society, 33 W. 39th St., New York City, from April 24 to 26, inclusive. On Wednesday morning, April 24, after the business meeting, at which President F. T. Llewellyn will preside, reports of various committees will be given and at 10:30 a. m. a technical session will be held, consisting of a symposium on How to Organize and Operate an Industrial Welding School. At the afternoon session, a paper on Physical Properties of Butt Welds, by G. Lobo, Westinghouse Electric & Manufacturing Co., and a paper on Welded Pipe Joints, the author to be announced later, will be presented. On Wednesday evening there will be a meeting of the Board of Directors.

The Thursday morning session will begin with a paper on Design of Joints for Welded Steel Structures by A. Vogel, General Electric Co., and will be followed by a paper on Welding in the Heating and Ventilating Industries by Professor S. E. Dibble, Carnegie Institute of Technology. Welding in the Aircraft Industry by R. M. Mock, Bellanca Aircraft Corp. will be given in the afternoon session, and Thermit Welding of Rail Joints for Main Line Track of Steam Railroads by J. H. Deppeler, Metal & Thermit Corp., while the annual dinner of the Society will be held in the evening.

On Friday morning there will be a symposium on

Welding in the Chemical and Process Industries. W. M. Dunlap, Aluminum Co. of America, will have a paper on Welding Aluminum in the Chemical Industry; N. B. Pilling, International Nickel Co., on The Production of Ductile Welds in Nickel and Monel Metal; and R. S. McBride, assistant editor, Chemical & Metallurgical Engineering, will discuss Welding in the Gas-Handling Industry and Requirements of Welding in the Chemical Field. The final paper on Welding of Pressure Vessels for High Temperatures and Pressures is by T. McLean Jasper, A. O. Smith Corp. On Friday afternoon the election of officers occurs, together with meetings of the various subcommittees and discussion of the future activities.

Electrical Engineers Meet in Cincinnati

AT THE THREE-DAY regional meeting of the Middle Eastern district of the A. I. E. E. held in Cincinnati, March 20-22, a well balanced technical program was presented.

Following the opening address, a short general technical session was held on the morning of the first day. "Recent Developments in Telephone Construction Practices" were reviewed by B. S. Wagner and A. C. Burroway of the Suburban Telephone Co. "Lighting of Airways and Airports" was discussed by H. E. Mahan, illuminating engineer of the General Electric Co. Today, 25 yr. after the first airplane flight, there are 15,128 mi. of airways operating and 1330 established airports, exclusive of army and navy fields. The Department of Commerce is responsible for the installation, operation and maintenance of the national airways and it is expected that by July 1, 1929, there will be 11,270 miles of lighted highways.

In large turbine generators, there is no convenient method for determining the iron losses under load. C. M. Laffoon and J. F. Calvert, both of the Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa., in a paper entitled, "Iron Losses in Turbine Generators" pointed out the factors that influence the change of iron loss with load.

In the afternoon of the first day, the Automatic Substation and Welding session was held. Four papers were presented: "Street Railway Power Economics," by J. A. Noertker of the Cincinnati Street Railway Co.; "Automatic Mercury-Arc Rectifier Substations in Chicago," by A. M. Garrett of the Commonwealth Edison Co.; "Arc Welding of Buildings and Bridges," by F. P. McKibben of the General Electric Co. and "Fabrication of Large Rotating Machinery," by H. V. Putman of Westinghouse Elec. & Mfg. Co.

Commonwealth Edison Co. Uses Mercury Vapor Rectifiers

Two automatic mercury-vapor rectifier substations having 3000-kw., 5000-amp., 600-v. rectifiers were described by Mr. Garrett. These rectifiers are the largest installed in this country and the reasons for selecting this equipment rather than the rotary type were enumerated. Mr. Putman reviewed the general application of fabricated steel in place of castings in the construction of the larger rotating machinery, discussed the reasons for the change and gave numerous illustrations of application.

One complete session was devoted to student activities, stressing the importance of the student branch as a part of the institute organization. On the afternoon of the second day one of the most interesting sessions, that dealing with high speed instruments and measurements, was held. "High Speed Photography in Electrical Engineering" was covered by H. N. Tenney of the Westinghouse Electric & Mfg. Co. This dealt primarily with a polar multi-exposure high speed camera and its use in the study of arc phenomena.

Lightning Discharges Recorded on Lines of Consumers Power Co.

"Oscillographs Recording Transient Phenomena" was presented by W. A. Morrison of the Bell Telephone Laboratories. Two instruments used for recording long and short transients were described. Another paper entitled, "A New Type of Hot Cathode Oscillograph and Its Application" was given by R. H. George of Purdue University. This oscillograph employs a new method of focusing the beam and can be made in portable form. It has been in service on the lines of the Consumers Power Co. since last fall and oscillographs of lightning discharges were shown.

New developments in "Bushing-Type Current Transformers for Metering" were discussed by A. Boyajian and W. F. Skeats, both of the General Electric Co. and "Excitation of Current Transformers under Transient Conditions" was covered by D. E. Marshall and P. O. Langguth, both of Westinghouse Electric & Mfg. Co.

At the last session held Friday morning, "Electrical Equipment of Bar Plate and Hot Strip Mills" was described in a paper by J. B. Ink of the American Rolling Mills Co. The paper described a new 11-stand mill recently installed by that company. Data from tests and experience on about 100 mi. of 66,000 v. circuit of the Union Gas & Elec. Co. with "Fused Arcing Horns and Grading Rings" were given by Philip Stewart. Fuses are used on insulator strings to interrupt the arc at times of flashover before the line relays operate to disconnect the current.

Artificial Lightning Used for Study on Transmission Lines

Operating experiences and problems which have resulted from the installation of a four-wire 120 and 208-v. secondary network system of the Union Gas and Electric Co. at Cincinnati were discussed by F. E. Pinckard of that company. Results obtained from 15 mo. operation indicate that with reasonable care no major difficulties need be expected.

Studies of artificial lightning surges on the Turners Falls transmission line by means of a cathode ray oscillograph were presented by K. B. McEachron and V. E. Goodwin of the General Electric Co. A portable impulse generator delivering 400 kv. has been constructed and impulses of definite form are applied to the line for study and experimentation. Elaborate and severe field tests made on high speed excitation equipment used with a 5385 kv-a. generator were described in a paper "Quick Sequence Generator Voltage Regulator" by E. J. Burnham of the General Electric Co.,

J. R. North of Stevens & Wood and I. R. Dohr of the Consumers Power Co.

On the evening of the first night of the meeting, a public demonstration was arranged. A battery of 16 flood lights on a balcony of the Gibson Hotel were switched on by a relay actuated by a radio wave from an airplane flying overhead. This was arranged by W. E. Stilwell, Jr. of the Columbia Engineering & Management Corp. and Fred Toy of the Union Gas & Electric Co. and was intended as a demonstration of airport and airway lighting control.

News Notes

OVER 40 INDUSTRIES that furnish material and equipment for chemical and associated industries will display their products at the Twelfth Exposition of Chemical Industries to be held during the week of May 6 at the Grand Central Palace, New York City. Over 400 exhibitors will occupy three floors of this structure. On Wednesday, May 8, a meeting is scheduled of the Technical Association of the Pulp and Paper Industry. Another exhibit of interest will be that of the Chemical Warfare Service of the U. S. Government, as well as an extensive display of all types of containers used in the field of the chemical industry.

TO AID in the development of the coal business of producers in territory served by the Norfolk and Western Railway and to render all possible aid to receivers and consumers of the product, a Coal Bureau was opened in Chicago on April 1, by the Norfolk and Western Railway Co., it was announced at the general offices of the railway at Roanoke, Va. The bureau is located in the Marquette Building, Room 519, Chicago, Ill.

ERIE CITY IRON WORKS, Erie, Pa., announces the appointment of the Schley-Nash Co., Columbia Bank Building, Fourth Ave. and Wood St., Pittsburgh, Pa., as sales representatives for its Pittsburgh territory.

VULCAN SOOT CLEANER Co. of Du Bois, Pa., has opened a New York office at 120 Liberty St., in charge of Fred W. Linaker, vice-president, assisted by C. H. Baker. Telephone is Barclay 8899.

OLSON & ENZINGER, INC., Century Bldg., Milwaukee, announces that the reorganization of its industrial advertising department has been put in charge of R. J. Nadherny, who recently came to this organization from Russell T. Gray, Inc., of Chicago.

WARREN STEAM PUMP CO., INC., Warren, Mass., has appointed as its district representative for Michigan the firm of Garrett Burgess, Inc., 5050 Joy Road, Detroit, Mich. It has also appointed as its representative the Hays Power Equipment Co., 205 West Wacker Drive, Chicago, Ill.

EFFECTIVE MARCH 15, 1929, Reading Iron Co., Reading, Pa., established an office at 402 Mutual Building, Kansas City, Mo., in charge of H. D. Pollard. John G. Cottle, who, for a number of years, was attached to the sales staff of the company's Chicago office, assumed, on April 1, the duties of railroad sales representative in the Chicago and western territory. This position was held by H. L. Shepard, resigned. O. L. McGinn has been engaged as salesman attached to the Chicago office.

R. Z. ZIMMERMANN has been elected vice president of The United Gas Improvement Co. in charge of purchasing, according to a recent announcement. He succeeds J. A. Pearson, who resigned after 40 yr. of service. The new official is a half-brother of John E. Zimmermann, president of the U. G. I. He is 35 yr. old and has had wide experience in the public utility industry, having been connected with Day & Zimmermann, Inc., since November, 1916. He will assume his new duties at once.

IOWA PUBLIC SERVICE Co. has let contract to Stevens & Wood, Inc., New York City, for installation of 3300-hp. high-pressure steam boiler at its central station in Waterloo, Iowa, bringing total plant capacity to nearly 15,000 hp. The 1929 project will represent an expenditure of about $225,000. R. H. Garrison is division manager in charge of the Waterloo work.

EX-CELL-O TOOL & MANUFACTURING Co., Detroit, Mich., has almost finished the $45,000 addition to its plant. The new building has been designed and constructed by the Austin Co., Cleveland, Ohio. The Austin Co. is also designing and erecting an office building and manufacturing plant for the Conveyor Co. of Los Angeles, Calif.

VIRGINIA PUBLIC SERVICE Co., Charlottesville, Va., has applied for permission to build a hydroelectric project in the vicinity of Wilson Springs, Va. The installation will consist of two 8000-hp. vertical reaction turbines and the development is estimated to cost about $400,000.

JOHN WOLFF, for many years chief engineer of the Cleveland Electric Illuminating Co., died suddenly on March 2 of heart disease. He was buried on Tuesday, March 5, at Lake View Cemetery, Cleveland. Mr. Wolff graduated from Stevens Institute of Technology in 1888, served with the United States Electric Company, of Newark, N. J., for a time, and then spent 10 yr. with the Brooklyn Edison Co. Following this, he was chief engineer for the Mahoning Valley Railroad for two years and since 1905 he had been with the Cleveland Electric Illuminating Co. Mr. Wolff had been for many years an active member of the Prime Movers Committee of the National Electric Light Assn. and was a member of many other technical and scientific organizations.

FLOOD STAGES of the Cedar River in Iowa recently halted electric and gas power service in Cedar Rapids, Vinton, Waverly and other communities in the valley. The Iowa Public Service Co. kept emergency crews working day and night to restore, protect and maintain service while the Vinton municipal plant tied in with the Iowa Canning Co.'s private plant to supply its community.

EFFECTIVE MARCH 1, new officers took over the management and operation of the Pittsburgh Valve, Foundry & Construction Co. Additions to the board are C. A. Anderson, Jr., long connected with the company as vice president and sales manager, who now becomes president and director of sales and A. V. Wadsworth, formerly secretary-treasurer and manager of the Westcott Valve Co. of East St. Louis, who becomes vice president and general manager. Mr. Anderson has been connected with the company in various capacities for over 20 yr.

The eastern division will be in charge of W. H. "Bill" Arnold, long connected with Pittsburgh Valve, Foundry & Construction Co.

Power Plant Construction News

Calif., Los Angeles—The Willard Storage Battery Co., East 131st Street and St. Clair Avenue, Cleveland, Ohio, plans installation of power equipment in proposed plant at South Gate, near Los Angeles, where tract of 10 acres of land has been secured, project to cost close to $450,000.

Colo., Salida—The Public Service Co. of Colorado, Denver, is said to be planning construction of a hydroelectric power plant in vicinity of Salida, to cost in excess of $200,000, with transmission line.

Ga., Savannah—The South Atlantic Packing & Provision Co., operated by the Georgia Ice Co., has concluded negotiations for purchase of tract of land on the Louisville Road, and plans construction of ice-manufacturing plant with initial capacity of close to 60 tons per day reported to cost in excess of $100,000, with equipment.

Idaho, Priest River—The Pacific States Pulp & Paper Co., Aberdeen, Wash., plans installation of power equipment in proposed new pulp and paper mill at Priest River, entire project to cost close to $1,000,000; a boiler plant will be built.

Ill., Chicago—The Merit Hardware Mfg. Co., 2125 West Rice Street, plans installation of power equipment in proposed new plant at Cicero Avenue and Augusta Street to cost about $300,000.

Ind., Indianapolis—The W. D. Allison Co., 905-7 North Alabama Street, plans construction of new one-story power plant for heating service in connection with factory for manufacture of physicians' furniture on Twenty-third Street, entire project to cost more than $80,000.

Ind., Knightstown—The Board of Trustees, Indiana Soldiers & Sailors Orphans' Home, L. A. Cortner, superintendent, is having plans drawn for a one-story power house at the institution, estimated to cost about $200,000, and will soon take bids on general contract. McGuire & Shook, 941 North Meridian Street, Indianapolis, are architects.

La., Shreveport—The Louisiana Oil Refining Corporation, Shreveport, plans construction of three pumping plants in vicinity of Bossier City, La., in connection with general expansion and betterment program reported to cost close to $100,000.

Mass., Dedham—The Fisher-Churchill Co., Dedham, has filed plans for a new one-story ice-manufacturing plant to cost about $55,000, with equipment.

Mich., Detroit—The Packard Motor Car Co., 1580 East Grand Boulevard, has filed plans for addition to power plant, reported to cost upward of $175,000, with equipment. Superstructure will begin at once.

Mo., St. Louis—The Wright Aeronautical Corporation, Paterson, N. J., will install power equipment in proposed branch plant at St. Louis, project to cost about $150,000.

Neb., Lincoln—The Board of Trustees, University of Nebraska, is said to have plans maturing for a new steam power plant on the campus, reported to cost close to $500,000, with equipment. Davis & Wilson, 525 South Thirteenth Street, are architects.

Neb., Omaha—Swift & Co., 1223 Leavenworth Street, meat packers, have filed plans for construction of one-story boiler plant addition, 65 by 100 ft., at local factory, estimated to cost about $45,000, with equipment. Headquarters are at the Union Stock Yards, Chicago, Ill.

N. J., Trenton—The Trenton Potteries Co. plans installation of power equipment, mechanical drying apparatus, etc., in proposed five-story addition to sanitary ware plant at North Clinton and Ott Street, estimated to cost $500,000.

N. M., Silver City—The City Council has authorized an immediate call for bids for a municipal water supply system, including motor-driven pumping equipment, air compressor and other mechanical equipment. Entire project will cost $115,000. Burton G. Dwyre, Silver City, is engineer.

Nev., Elko—The Board of Trustees, Starr Valley District, is planning an appropriation of $30,000, for the installation of an electric distributing system for power service.

N. Y., Buffalo—The Arrow Head Steel Products Company, 89 Oak Street, plans installation of power equipment in proposed addition to plant on Colgate Street to cost about $100,000. Headquarters are at Minneapolis, Minn.

N. Y., Buffalo—Board of Trustees, Emergency Hospital Sisters of Charity, 669 Main Street, L. J. Schwab, chairman, is considering an addition to power plant at the institution, estimated to cost close to $100,000, with equipment.

N. Y., Utica—The Skenandoa Rayon Corporation, Utica, has engaged W. E. S. Dyer, Land Title Building, Philadelphia, Pa., engineer, to prepare plans for a power plant in connection with proposed rayon mill units, reported to cost more than $350,000, with equipment. Entire project will cost $3,000,000.

N. Y., Waterville—George W. Haxton & Son, Oakfield, N. Y., will install power equipment in connection with extensions and improvements in food canning plant at Waterville, project reported to cost more than $80,000.

Ohio, Akron—General Tire & Rubber Co., Akron, will install power equipment in proposed new rubber mill in South, on site soon to be selected in Georgia or Alabama, entire project to cost more than $2,500,000. A boiler plant will be built. William O'Neil is president.

Ohio, Toledo—The Hupp Motor Car Corporation, Detroit, Mich., will install power equipment in proposed addition to crank shaft manufacturing plant at Toledo to cost approximately $450,000.

Pa., Bristol—Keystone Aircraft Corporation plans installation of power equipment in proposed addition to assembling plant to cost approximately $250,000.

Pa., Philadelphia—The Publicker Commercial Alcohol Co., Bigler Street and Delaware Avenue, has filed plans for extensions and improvements in steam power house to cost close to $50,000, with equipment.

Pa., Philadelphia—The Reyburn Mfg. Co., Thirty-second Street and Allegheny Avenue, plans installation of power equipment in a five-story addition to its paper products plant to cost $350,000. LeRoy B. Rothschild, 4408 Walnut Street, Philadelphia, is architect.

S. C., Beaufort—The Low Head Water Power Co., Beaufort, recently organized, is reported planning hydroelectric power plant on Jericho Creek, to cost more than $150,000, with transmission system.

S. C., Spartanburg—The Fairforest Finishing Co., H. A. Ligon, Spartanburg, treasurer, recently organized, will install power equipment in proposed new textile bleachery and finish-plant on North Tyger Street, to cost more than $750,000. The Lockwood Greene Engineers, Inc., 100 East Forty-second Street, New York, are engineers.

S. D., Philip—The Paul S. Kerfoot Public Utilities Co., Pioneer Building, St. Paul, Minn., is said to be planning extensions and improvements in power plant at Philip, including installation of additional equipment for increased capacity. T. C. Scruby is local manager at Philip.

Texas, San Antonio—The Grayburg Oil Co., Maverick Building, San Antonio, will install power equipment in proposed oil refinery on tract of land recently acquired at South San Antonio, entire project to cost close to $1,000,000; a boiler plant is planned.

Texas, Schulenburg—The Carnation Milk Products Co., Oconomowoc, Wis., plans installation of power equipment in proposed milk condensing plant at Schulenburg to cost more than $200,000. A site has been secured.

Utah, Richfield—The Telluride Power Co., Provo, Utah, is said to be planning a new steam-operated electric power plant in the Sevier Valley, near Richfield, to cost about $200,000, with equipment and transmission line. H. B. Waters is general manager.

Va., Gore—The Eastern Silica & Chemical Co., Winchester, Va., John F. Penrose, head, plans installation of a Diesel engine and generator in connection with extensions and improvements in grinding mill at Gore.

Wash., Palouse—Power equipment will be installed in proposed new pulp mill to be constructed on local site by A. L. Maxwell, Palouse, and associates, estimated to cost $150,000. A company is being organized to carry out the project.